The State of New Jersey
Department of Environmental Protection

Exceptional Event Demonstration Analysis For Ozone During May 25 -26, 2016

May 31, 2017

Preface

On May 1, 2016, a series of wildfires started in the Fort McMurray area of Alberta Canada. The wildfires could not be extinguished and spread to over 1,500,000 acres until it was declared under control on July 5, 2016. The fires, which were the biggest catastrophe in Canada in 2016, are still smoldering as of today. During May 25 and 26, 2016, the ozone air quality in New Jersey experienced uncommonly high exceedances of the 75 parts per billion National Ambient Air Quality Standard levels at 16 monitors on May 25, 2016 and 10 monitors on May 26, 2016. Lesser impacts to air quality were still present in the days following the exceptional event. The structure of this document is based on the EPA's "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations," dated September 16, 2016. The exceptional event demonstration conducted by the New Jersey Department of Environmental Protection analyzes the influence of the Canadian wildfires on New Jersey's air quality, the associated meteorology that characterized the event, assesses historical ozone air quality trends at New Jersey monitors, and demonstrates that ozone air quality would not have exceeded the ozone NAAQS during this time period if not for the influence of the wildfire pollution. New Jersey is seeking the exclusion of ozone air quality data for the May 25 and 26, 2016 time period.

Table of Contents

List of Tables

List of Figures

List of Attachments

Attachment 1: Animations of the Carbon Monoxide and Black Carbon Levels over the United States in May 2016 (available for viewing at http://www.nj.gov/dep/baqp/)

Executive Summary

A wildfire in Fort McMurray, Alberta, Canada, from May 1 to July 5, 2016 consumed 589,995 hectares (about 1,500,000 acres) over 5,900 square kilometers, forced over 80,000 residents out of their homes, and destroyed about 2,400 buildings. Because of the emissions from this Canadian wildfire, sixteen (16) out of seventeen (17) monitors in New Jersey recorded exceedances of the 70 ppb 8-hour average ozone NAAQS on May 25, 2016. All sixteen stations also exceeded the prior 75 ppb 8-hour ozone NAAQS, and two stations exceeded the even older 84 ppb 8-hour ozone NAAQS. On May 26, 2016, ten exceedances were recorded in New Jersey of the 70 ppb 8-hour average ozone NAAQS of 2015. Nine stations also exceeded the prior 75 ppb 8-hour ozone NAAQS, and five stations exceeded the even older 84 ppb 8-hour ozone NAAQS. The Environmental Protection Agency (EPA) promulgated the Exceptional Events Rule in 2007.

The Clean Air Act (CAA) section 319(b) allows the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of the national ambient air quality standards (NAAQS). This document presents the following evidence that the wildfires in Alberta, Canada caused exceedances of the ozone standard in New Jersey on May 25 and 26, 2016. The evidence presented includes the following.

- Satellite observations of the levels of Aerosol Optical Depth and Carbon Monoxide taken by National Oceanic and Atmospheric Administration's (NOAA) satellite on the days of and preceding the exceptional event show that the wildfire emissions from Fort McMurray moved to New Jersey to further support the HYSPLIT back trajectories.
- The location of the fires and the resulting levels of smoke in the air were traced by satellite from the location of the fires in Fort McMurray, through the mid-western United States, and to New Jersey using NOAA's Hazard Mapping System (HMS) consisting of real-time satellite imagery loops.
- Ozone levels in the states downwind from Fort McMurray became greatly elevated and unhealthful after the proper weather conditions developed to enhance ozone formation (i.e.; greater temperature and sunshine, and favorable wind conditions). The United States Environmental Protection Agency's (EPA) Air Quality System (AQS) database, reports the ambient air levels of ozone to be unhealthful in the states upwind of New Jersey on the days preceding the exceptional event in this state and the rise of ozone levels can be traced back from New Jersey through the states to our west to the fires. The "aged" wood smoke in the air that caused these elevated levels in these upwind States would arrive in New Jersey on May 25 and 26, 2016 to cause the exceedances of the ozone levels in New Jersey.
- An analysis of days having similar meteorological conditions as occurred on May 25 and May 26, 2016, but without the presence of wildfires, show that ozone levels in New Jersey are typically very low when the air moves through the area of Fort McMurray to New Jersey.
- Ambient air levels of potassium, a known tracer compound for wood smoke, were found in greater levels within the air of the states upwind from New Jersey on the days that coincided with elevated ozone levels at these upwind states..

- Visual observations, as evidenced by pictures taken within New Jersey, show that an apparent haziness existed on the days of the exceptional event compared to the days immediately following the event.
- Ozone levels in New Jersey were exceptionally high with most of the monitors recording levels greater than the 98th percentile of the highest ozone levels typically monitored during the last five years (2012 – 2016).
- New Jersey monitored elevated 24-hour fine particulate (PM2.5) levels throughout the state on May 25 and 26, 2016. These levels were similar to the levels found in New Jersey's air when a more nearby wildfire earlier in the month caused elevated levels of fine particulate matter. The Colliers Mills ozone monitor, located directly upwind from this nearby fire, did measure elevated levels of ozone.
- HYSPLIT back trajectories on the days of the exceptional event in New Jersey show that the wind patterns would have carried the wildfire emissions from the air around Fort Mc Murray, Canada to reach New Jersey on May 25 and 26, 2016.
- Overlays of the satellite image of wood smoke with the ground level monitored ambient air levels of ozone show that the movement of the smoke plume from the location of the wildfires to New Jersey match with the elevated ozone levels on the ground.

Justification to support that an exceptional event occurred in New Jersey causing unusually high levels of ozone to form because of emissions from wildfires in Alberta, Canada.

I. A Narrative Conceptual Model and a Discussion of the Event That Led to Exceedances at New Jersey's Monitors

1. A description of New Jersey's ozone nonattainment areas

New Jersey is associated with two multi-state nonattainment areas: the Northern New Jersey-New York-Connecticut (NJ -NY-CT) nonattainment area and the Southern New Jersey-Pennsylvania-Delaware-Maryland (NJ-PA-DE-MD) nonattainment area. The NJ-NY-CT nonattainment area includes counties in the states of New York and Connecticut and the New Jersey counties of: Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union, and Warren. The NJ-PA-DE-MD nonattainment area includes counties in the states of Pennsylvania, Delaware, and Maryland and the New Jersey counties of: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Ocean, and Salem. The entire State of New Jersey is not attaining the ozone health standard of 70 parts per billion (ppb).

2. Non-event ozone formation in the New Jersey nonattainment areas

New Jersey typically experiences high ambient air ozone levels in the summer months. This section of the document discusses the normal patterns of ozone formation in New Jersey's air so the reader can understand how the exceptional event caused by the Fort McMurray fires differs from the usual weather patterns and locations of emissions that normally cause New Jersey to exceed the National Ambient Air Quality Standard for ozone.

The evolution of elevated ozone episodes in the eastern U.S. often begins with the movement of a large high pressure area from the Midwest to the middle or southern Atlantic states, where it assimilates into and becomes an extension of the Atlantic (Bermuda) high pressure system.[1] During its movement east, the air mass accumulates air pollutants emitted by large coal-fired power plants and other sources located outside the Ozone Transport Region (OTR). As the air mass passes over the eastern U.S., sources within the OTR contribute to the air pollution. These expansive weather systems are conducive to the formation of ozone by creating a vast area of clear skies and high temperatures. These two prerequisites for elevated ozone formation are further compounded by a circulation pattern favorable for pollution transport over large distances. In the worst cases, the high pressure systems stall over the eastern U.S. for days, creating ozone episodes of strong intensity and long duration.

[1] **The State of New Jersey Department of Environmental Protection, State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard 8-Hour Ozone Attainment Demonstration, Chapter 2, Final, October 29, 2007**

One transport mechanism that can play a key role in moving pollution long distances is the nocturnal low level jet stream. The jet is a regional scale phenomenon of higher wind speeds that often forms during ozone events a few hundred meters above the ground. It can convey air pollution several hundreds of miles overnight from the southwest to the northeast, directly in line with the major population centers of the Northeast Corridor stretching from Washington, D.C. to Boston, Massachusetts. The nocturnal low level jet extends the entire length of the corridor from Virginia to Maine, and has been observed as far south as Georgia. It can thus be a transport mechanism for bringing ozone and other air pollutants into the OTR from outside the region, as well as to move locally formed air pollution from one part of the OTR to another. Other transport mechanisms occur over smaller scales, including land, sea, mountain, and valley breezes that can selectively affect relatively local areas.

The different transport regimes into and within the OTR provide a conceptual picture of unhealthy ozone air quality days. Normally air cools as elevation increases above ground level. However, a nocturnal temperature inversion can occur after sunset if the ground cools faster than the air above it. In this instance, air temperature increases with elevation, which creates a stable boundary layer that prevents the vertical movement of air and thus traps pollutants near the ground. The stable boundary layer extends from the ground to only a few hundred meters in altitude. The air movement within the stable boundary layer is also minimal due to friction from the ground, and ground-level structures. Above this stable boundary layer, a nocturnal low level jet can form with higher velocity winds due to the absence of the frictional forces. Ozone contained in the low level jet is unable to mix down to the ground because of the presence of a temperature inversion, and is thus not subject to removal on surfaces or chemical destruction. Ozone in high concentrations can be entrained in the nocturnal low level jet and transported several hundred kilometers downwind overnight. The next morning, as the sun heats the Earth's surface, the nocturnal boundary layer begins to break up, and the ozone transported overnight mixes down to the surface where concentrations rise rapidly, partly from mixing and partly from ozone generated locally. By the afternoon, abundant sunshine combined with warm temperatures promotes additional photochemical production of ozone from local emissions. As a result, ozone concentrations reach their maximum levels through the combined effects of local and transported pollution.

During unhealthy ozone exceedance episodes associated with high pressure systems, these multiple transport features are embedded within a large ozone reservoir arriving from source regions to the south and west of the OTR. Thus, ozone exceedance episodes can contain elements of long range air pollution transport from outside the OTR, regional scale transport within the OTR from channeled flows in nocturnal low level jets, and local transport along coastal shores due to bay, lake, and sea breezes. These typical patterns of wind flows that usually result in unhealthful ozone levels were not present in New Jersey on May 25 and 26, 2016 when air flowed from a direction not normally associated with high ozone levels in New Jersey as explained later in this document.

Ozone formation within the OTR is primarily due to nitrogen oxides (NOx), but volatile organic compounds (VOCs) are also important because they influence how efficiently ozone is produced by NOx, particularly within urban centers. Recent studies suggest that aged wildfire smoke, containing VOC's, transported into urban areas like New Jersey where an abundant supply of

NOx exists, will lead to the creation of higher ozone levels because of the extra VOC from the wood smoke.[2] This is discussed in more detail in the Conceptual Model of Ozone Formation from Wildfires section of this document.

3. Wildfire description

A wildfire in Fort McMurray, Canada started on May 1, 2016 and was not declared to be under control until July 5, 2016. This massive wild fire consumed 589,552 hectares (about 1,500,000 acres) over 5,900 square kilometers.[3] Over 80,000 residents were forced out of homes during this episode and 2,400 buildings were destroyed. More than 2,000 firefighters fought the blaze over this extended period. Approximately 3.77 billion Canadian dollars in damage resulted from this disaster and was called the most expensive disaster in Canadian history.[4]

The fire spread very rapidly between May 1 and May 20, 2016.[5] According to one news source:[6]

> "The large swaths of green that ring Fort McMurray are made up of trees that have adapted over time to depend on fire for growth. Natural Resources Canada says that in the boreal forest fire 'is as crucial to forest renewal as the sun and rain.' During a Tuesday press conference in Fort McMurray, Bernie Schmitte from Alberta Forestry elaborated on why the region is going up in smoke.
>
> Spruce trees, pine trees, they like to burn. They have to burn to regenerate themselves. Those species have adapted to fire. Their cones have adapted to open up after the fire. The trees have adapted so that once they're old enough, and decadent and need to be replaced, they are available to fire so they burn." He called the black spruce, white spruce and aspen trees "volatile fuels" in the fire-dependent ecosystem.
>
> Black spruce, which grows across the continent from Newfoundland to Alaska, can grow as high as 30 meters in areas with well-drained mineral soils. According to the U.S. Fire Service, even the arrangement of the black spruce's branches and cones help spur "easy ignition and torching," all the while protecting the tree's seeds from fire. The tree's cones also release seeds soon after a blaze. After a fire burns through the moss or lichen layers atop the soil, it's easier for the seeds to thrive in burn sites.
>
> White spruce forests are slightly less likely to go up in flames than black spruce, but can still ignite easily. In a community of trees that are similar in size of age, fires

[2] "Significant Enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires", M. Val Martin et al, Journal of Geophysical Research, Vol. 111, D23S60, doi:10.1029/2006JD007530, 2006

[3] http://www.cbc.ca/news/canada/edmonton/fort-mcmurray-wildfire-now-considered-under-control-1.3664947

[4] http://www.cbc.ca/news/canada/edmonton/almost-biblical-fort-mcmurray-wildfire-named-biggest-weather-event-of-2016-1.3913871

[5] http://wildfiretoday.com/2016/05/27/animation-of-the-spread-of-fort-mcmurray-fire/

[6] http://news.nationalpost.com/news/canada/why-the-boreal-burns-the-trees-surrounding-fort-mcmurray-are-hard-wired-for-fire

tend to be small, but infernos can occur in extreme fire years. Some scientists believe fire severity for white spruce trees will increase with global warming.

Aspens, another tree type singled out by Schmitte, have been hammered by recent droughts in the region. Last summer, Erica Samis, manager of forest health and adaptation with Alberta Agriculture and Forestry, told the Calgary Herald she had been noticing the normally full, green deciduous trees were shriveling up and turning brown from the lack of rain. Drought can make dried-out trees more vulnerable to fire as well.

Jack pine is also found in large parts of Alberta. The species thrives after forest fires, the heat opening up pine cones and releasing seeds. The burns also get rid of competing plants and shrub. The species of pine is among the most common trees in the boreal region, which stretches across half of Canada's land mass."

The fire produced massive amounts of smoke that was transported hundreds of miles.[7,8,9] Figures 1a, 1b, and 1c show the extent of the Canadian Wildfires.

Figure 1a: Picture of wood smoke from Fort McMurray, Canada

[7] http://media.globalnews.ca/videostatic/376/534/2016-05-04T05-14-16.333Z--1280x720.jpg
[8] http://i2.cdn.cnn.com/cnnnext/dam/assets/160506191346-05-mcmurray-wildfire-0506-super-169.jpg
[9] http://www.brookfieldrps.com/wp-content/uploads/2016/05/Fort-McMurray-Wildfires.jpg

Figure 1b: Picture of Wood Smoke from Fort McMurray, Canada

Figure 1c: Picture of Wood Smoke from Fort McMurray, Canada

Local and regional effects of the massive fire upon air quality were seen at monitors located near Fort McMurray.[10] In the area near Fort McMurray, 1-hour PM2.5 levels exceeded 5,000 ug/m^3 and 1-hour ozone exceeded 250 ppb. Estimates of the emissions that caused these high levels in the ambient air were estimated in the millions of tons. According to one report concerning the extreme quantity of emissions released by this wildfire:[11]

> "Werner Kurz, is a senior research scientist at the Canadian Forest Service and head of its carbon accounting team. He said he generally estimates that for every hectare of forest land consumed in a fire like this one, about 170 tons of carbon-dioxide-equivalent emissions — so dubbed because they actually include not only carbon dioxide but also methane and nitrous oxide, two other greenhouse gases — head into the atmosphere. That would mean that this single fire has contributed — for a rough estimate — some 85 million tons of carbon-dioxide-equivalent emissions."

4. Conceptual model of ozone formation from wildfires (Interaction of emissions and chemistry of event) and ozone chemistry that characterized the episode including the meteorological conditions and transport patterns

Smoke from wildfires has been known to cause elevated ozone levels downwind and expanding observational evidence has demonstrated a clear connection between vegetation fires and photochemical ozone formation within their plumes.[12] Long-range transport of boreal wildfire emissions can result in greater levels of carbon monoxide (CO), organic and black carbon (BC) aerosol, NOx, PM2.5, and aerosol mass downwind of the fire location. Also, greater amounts of CO in the plume can also enhance ozone formation.[13] Higher CO levels within the smoke plume produced by the Fort McMurray wildfires are as shown in Figure 10.

In a study of the impacts from a Quebec, Canada wildfire event in northeastern U.S.,[14]

> "The CO mixing ratios and aerosol mass loadings in the smoke plume were comparable to the most intense combustion pollution plumes and anthropogenic haze events to have ever impacted these rural New England sites."

This study also reported that ozone levels within the plume are also much greater, with ozone levels in the plume reaching 75 ppbv in one instance.

---

[10] https://www.alberta.ca/documents/FtMcMurray-AirMonitoringDataMemo.pdf

[11] https://www.washingtonpost.com/news/energy-environment/wp/2016/05/20/the-fort-mcmurray-fires-stunning-pulse-of-carbon-to-the-atmosphere/?utm_term=.a5e684a64f86

[12] "Soot carbon and excess fine potassium: Long range transport of combustion-derived products", Andreae, M.O., Science, 1983, 220, 1148-1151

[13] "Significant Enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires", M. Val Martin et al, Journal of Geophysical Research, Vol. 111, D23S60, doi:10.1029/2006JD007530, 2006

[14] "A major regional air pollution event in northeastern United States caused by extensive forest fires in Quebec, Canada", L.J. DeBell, R. Talbot, J. Dibb, Journal of Geophysical Research, Vol. 109, D19305, doi:10.1029/2004JD004840, 2004

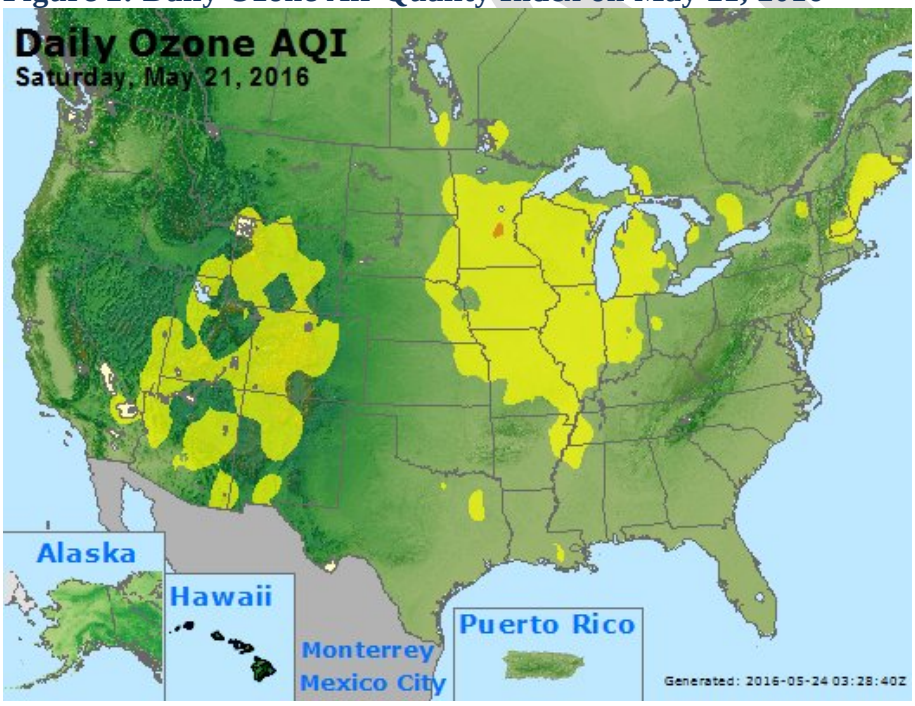
Smoke from wildfires also appears to have a greater effect on enhancing ozone formation in urban areas compared to rural areas. One previous study of Canadian wildfires (not related to this exceptional event) found that in urban areas, or any region modified by nearby NOx sources, ozone levels were more sensitive to long-range fires compared to less populated or polluted regions."[15]

In this study, researchers proved that:

> "Both observations and model results show enhanced O_3 from air transported from the Northwest Territory. The model results imply that, during the period of strongest fire influence, a 10 to 30 ppbv enhancement of O_3 throughout a large region of the central and eastern United States was due to these fires."

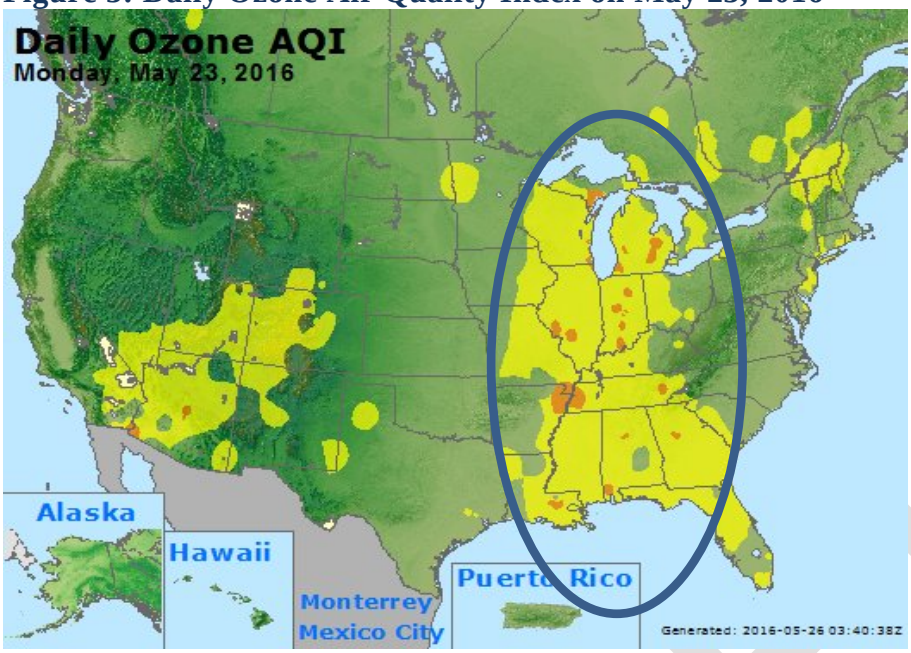
On May 21, 2016, high ozone levels were located over the Mississippi Valley (as shown by the yellow areas in Figure 2) and continued to travel eastward due to accumulating wildfire smoke being held aloft. By May 23, 2016, isolated areas of Unhealthy for Sensitive Groups (USG) ozone levels were developing due to trapped wildfire smoke in a slow moving high pressure system sitting over the region, as shown by the orange areas in Figure 3.

Figure 2: Daily Ozone Air Quality Index on May 21, 2016



[15] "Ozone production from Canadian Wildfires during June and July of 1995", S.A. McKeen et al, Journal of Geophysical Research, Vol. 107, No. D14, 4192, 10.1029/2001JD000697, 2002

Figure 3: Daily Ozone Air Quality Index on May 23, 2016



High ozone levels can be observed during episodes of high pressure due to a pattern of sinking air associated with the system and poor atmospheric ventilation. This causes the dirty air to slowly travel within the high pressure system as it travels farther eastward. Smoke from the Fort McMurray wildfire was transported to the Mississippi Valley where it was held aloft for several days. In Figure 4, high pressure noted by a blue "H" was observed on May 23, 2016, as highlighted by the blue circled area. Referring back to Figure 3 on the previous page, high ozone levels were also observed in the same blue circled location as the high pressure system.

Often, 850mb temperatures are analyzed to determine where warm and cool air is located aloft. This can be important during ozone season because warm temperatures aloft can be conducive for ozone production. Warmer than normal 850mb temperatures in combination with abundant sunlight and elevated wildfire smoke created favorable conditions for ozone production to occur aloft gradually as the plume moved farther eastward. As seen in Figure 5, by May 24, 2016, larger areas of unhealthy ozone air quality developed further eastward as noted by the orange areas. As seen in Figure 6, by May 25, 2016, the high pressure system had moved offshore, and the area was characterized by southwesterly winds (due to clockwise rotation around the high pressure system, indicated by blue arrows over West Virginia and Virginia) and an approaching cold front (indicated by red arrows) funneled the dirty air into the northeast where it continued to produce wildfire induced ozone.

Figure 4: Location of High Pressure System and Dirty Air Over Central U.S. on May 23, 2016

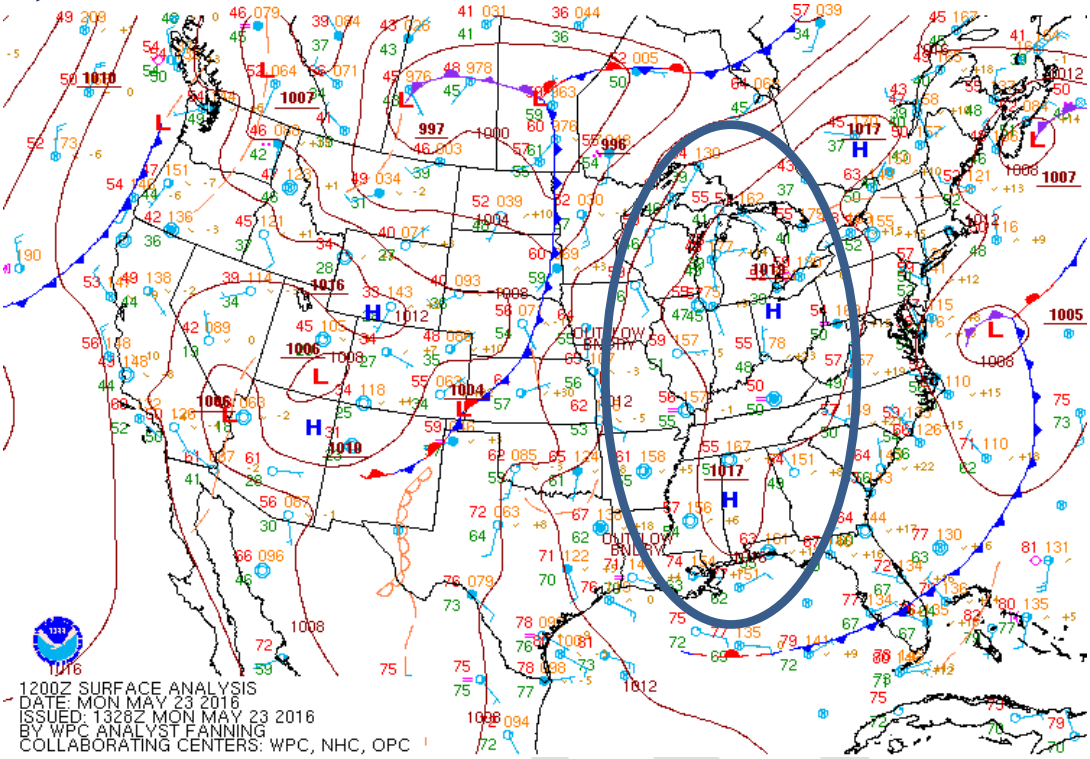


Figure 5: Daily Ozone Air Quality Index on May 24, 2016

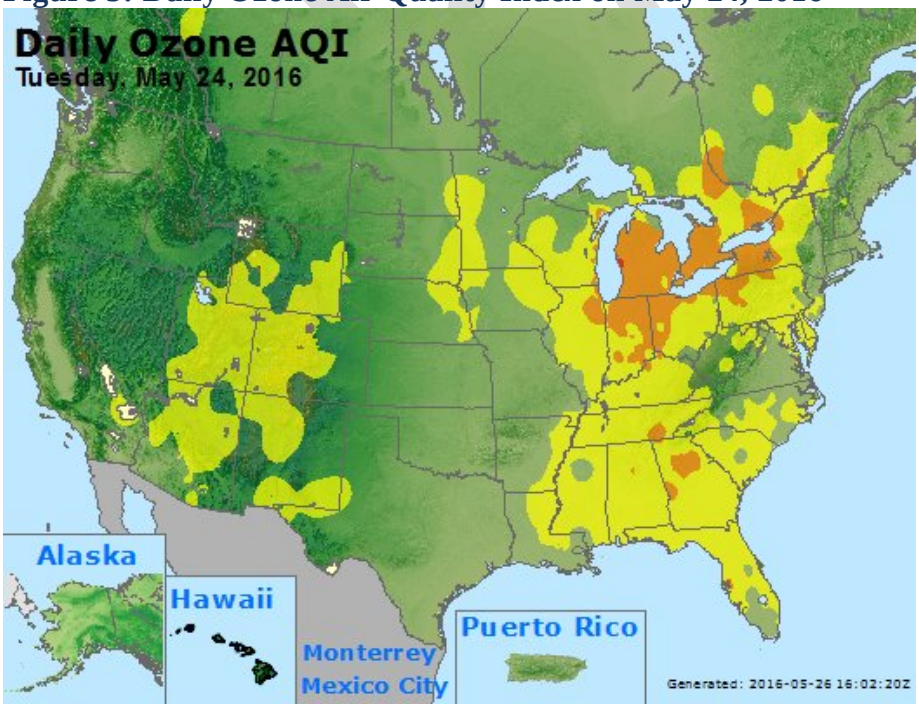


Figure 6: Movement of High Pressure System to the East on May 25, 2016

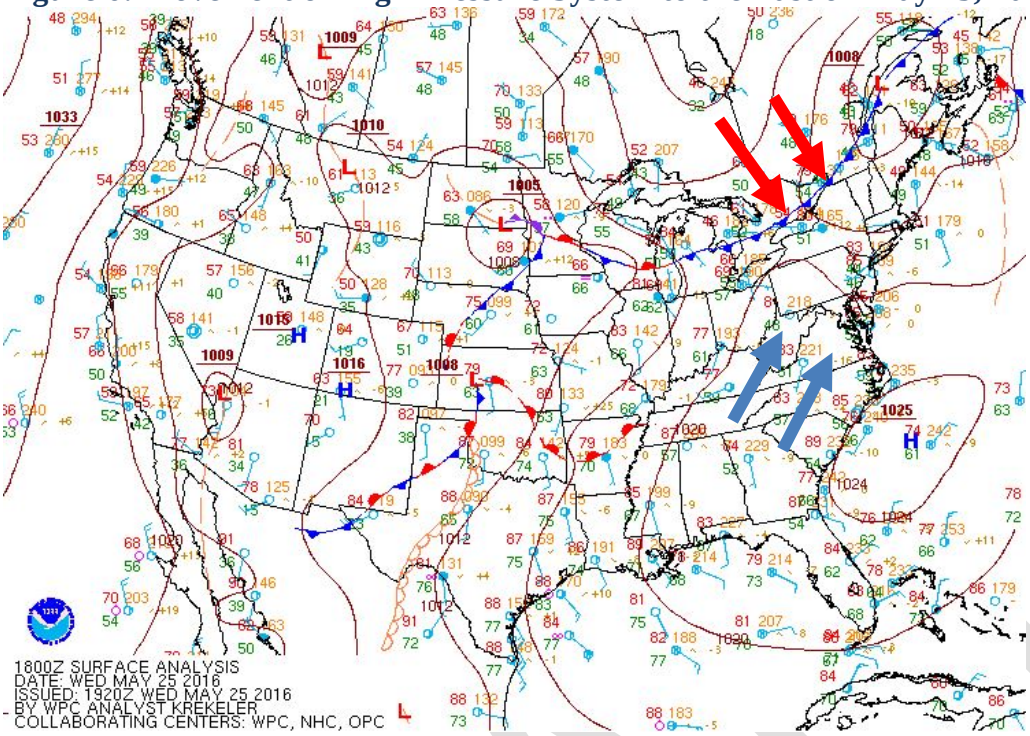
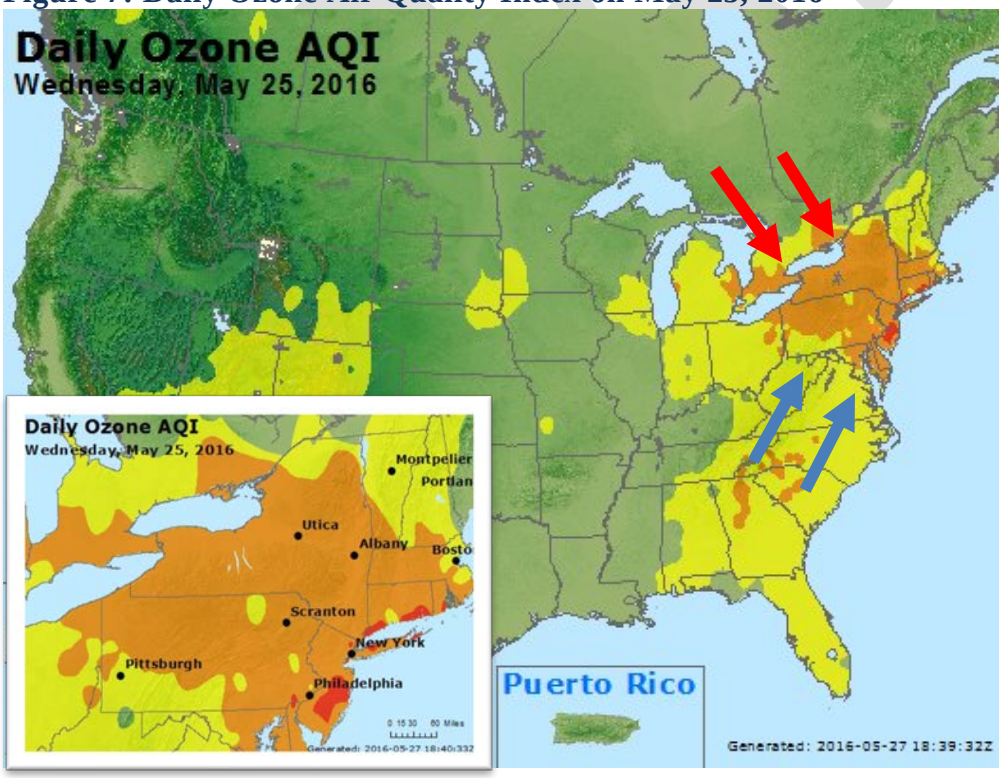


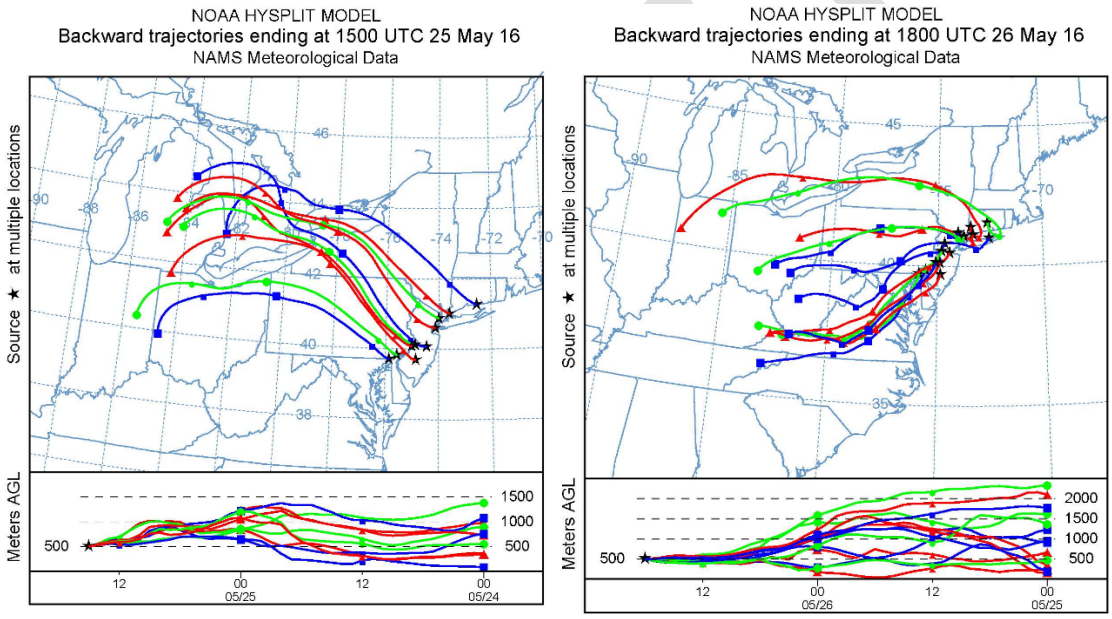
Figure 7: Daily Ozone Air Quality Index on May 25, 2016



In Figure 7, also for May 25, 2016, the movement of the high pressure system and the funneling of the unhealthy ozone air quality into the northeast is indicated by the blue arrows.

The plume of polluted air on May 25, 2016, shows a regional impact from the wildfires on ozone air quality across the eastern coast of the Unites States. Multiple states within the OTR experienced unhealthy air quality (orange area) with the more severe unhealthy ozone air quality levels noted by the red areas in Southern New Jersey, portions of Long Island, New York, and along the southern coast of Connecticut. Back trajectories on May 25 and 26, 2016 (see Figure 8) indicate that air aloft at 1500m was mixing down to the 500m level and below due to the influence of high pressure. This pattern allowed any polluted air aloft to mix down to the surface over the course of the two-day exceedance period where New Jersey saw high ozone levels.

Figure 8: HYSPLIT Backward Trajectories on May 25 and 26, 2016

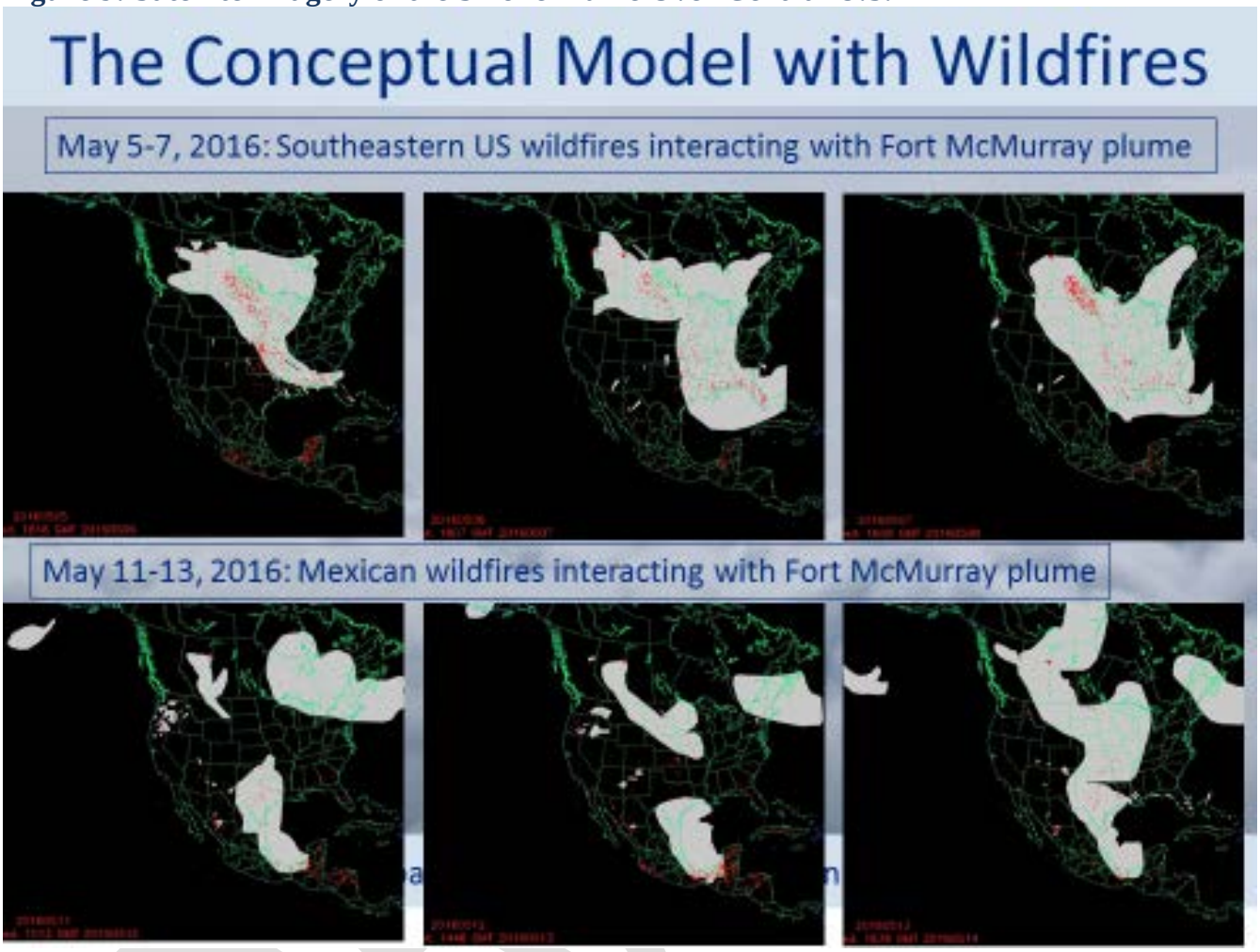


The movement of this "dirty ozone air" is evidenced in Figure 9 by satellite imagery on the days of the exceptional event.[16] The images in Figure 9 clearly show that the smoke emissions originating from the Fort McMurray fires, combined with emissions occurring from another wildfire in Mexico, moved across the U.S. during the month of May to affect the air quality levels in New Jersey and the surrounding region on May 25 and 26, 2016.

After May 21, 2016, 850mb wind patterns allowed the plume from the Fort McMurray fires to merge with that from the Mexican fires over the upper Midwest States, which enhanced ozone production there. The images in Figure 9 below show the merging of the smoke plumes over the Midwestern U.S., as evidenced by the BC and CO levels, and their slow movement towards New Jersey.

[16] The Figure 9 slide and the content of the discussion are taken from a presentation provided by the State of Connecticut, Department of Energy and Environmental Protection.

Figure 9: Satellite Imagery of the Smoke Plume Over Central U.S.



For electronic viewing of this document, animations are provided in Attachment 1 for Figures 10 and 11 that demonstrate the levels of CO from May 1-31, 2016, and for BC from May 15-26, 2016. This animation is not available in the paper copy of this document. Daily column CO from OMI (Ozone Monitoring Instrument), shows the influence of both the Canadian and the Mexican Wildfires. In the animation, carbon monoxide levels, as shown by the darker orange to red colors, downwind of the Fort McMurray fires can be seen to increase across eastern Canada and the eastern U.S. as the fires occurred through the month of May 2016. Black carbon levels, as shown in the OMI animation as a red to darker green colors to reflect the increased levels of black carbon, from recent wildfire smoke. The CO images in Figure 10 from the satellite monitoring system measured a plume of smoke based on the carbon monoxide produced by wood combustion and originating primarily in Canada. The satellite measurements indicate the plume moved across the U.S. due to the high pressure system as mentioned previously.

Figure 10: Animation of CO Levels from the Smoke Plume Over Central U.S.

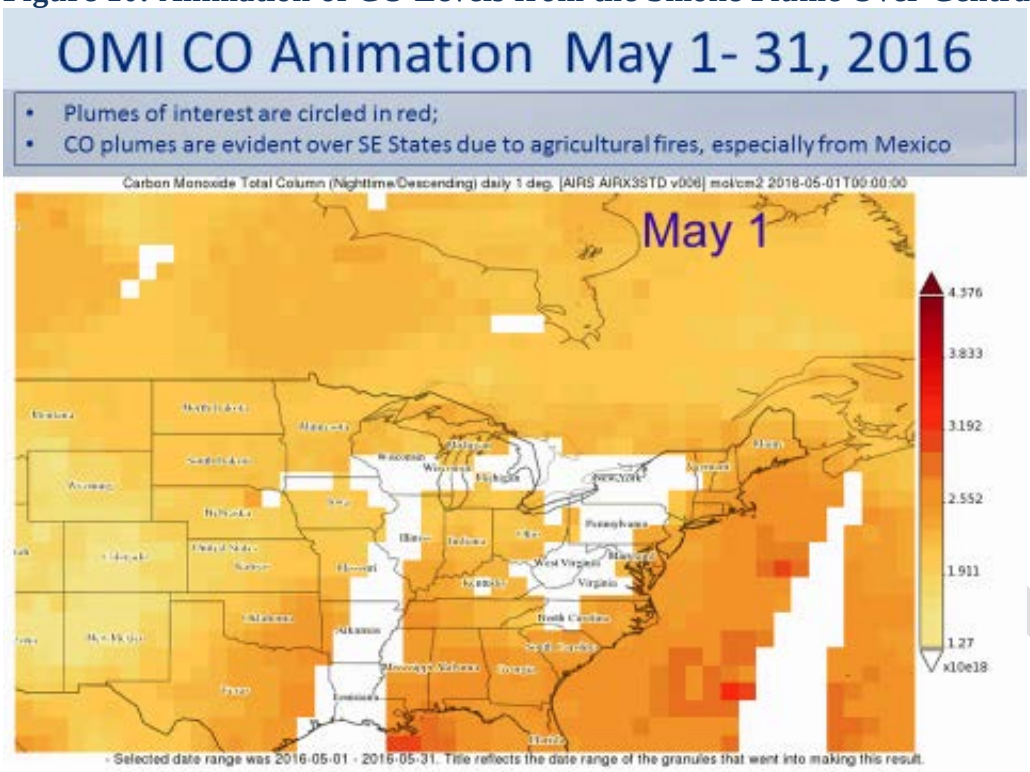
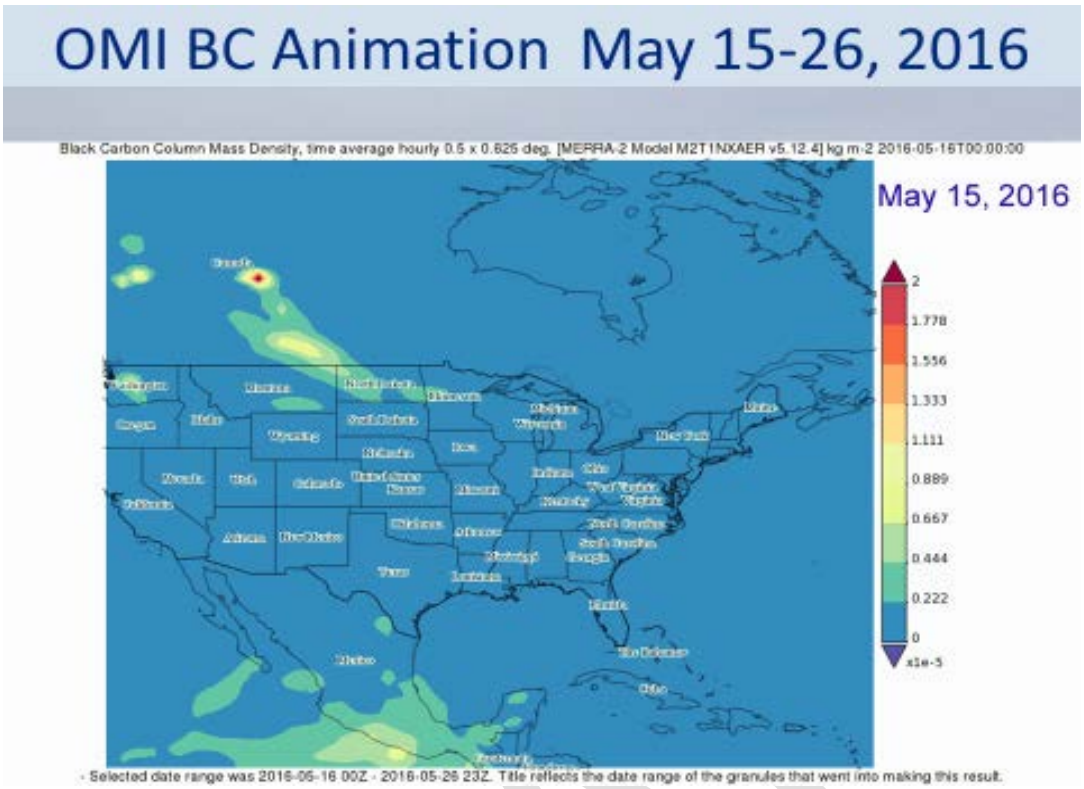


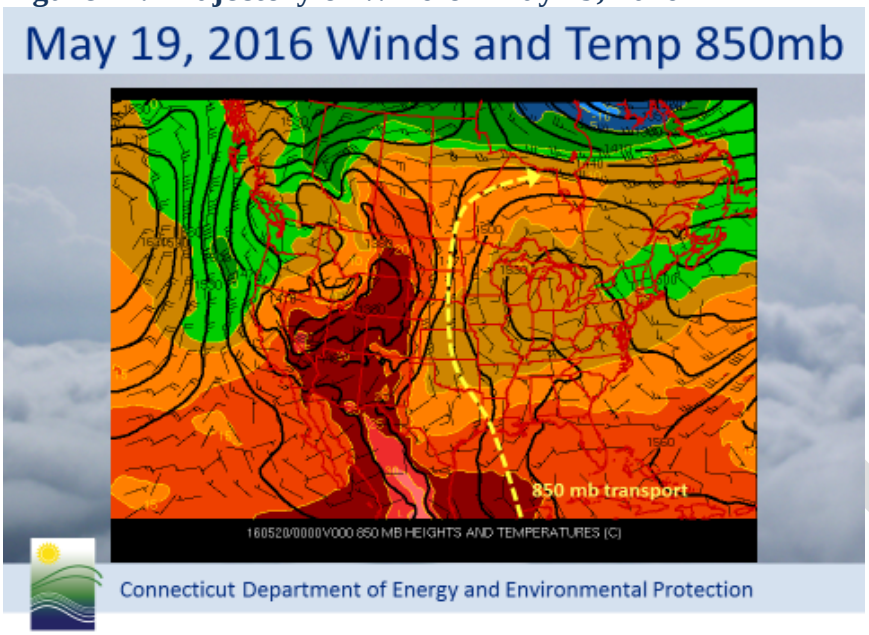
Figure 11: Animation of Black Carbon Levels from the Smoke Plume Over Central U.S.



Figures 12 – 35, provided by the State of Connecticut, show 850mb wind patterns, aerosol optical depths, and NOAA's HMS smoke plumes from May 19 to May 26, 2016. Aerosol optical depth is a measure of particles (smoke) in the atmosphere that can block sunlight by absorbing or by scattering light. Aerosol optical depth measures how much direct sunlight is prevented from reaching the ground by these particles. The smoke and fire imagery on these days are also presented to show that the winds carried the smoke plume from the Midwest to New Jersey. The location of the fires in Canada and the Midwest are also shown to be the source of the smoke plume measured by the satellites as indicated by the red dots in Figures 17, 20, 23, 26, 29, 32 and 35.

The 850mb temperature and wind pattern maps are presented to illustrate the extent of heat aloft providing favorable conditions for ozone production to occur. The orange and red colors indicate warm temperatures and the green and blue colors indicate cooler temperatures.

Figure 12: Trajectory of Wind on May 19, 2016



As seen in Figure 13 for May 19, 2016, the aerosol optical depth, the measure of smoke in the atmosphere that is blocking sunlight, is indicated by the gray areas and provides a demonstration of the extent of the smoke plume from the Fort McMurray wildfire during the week before the wildfire impacted New Jersey's ozone air quality. The daily progression of warmer temperatures and the eastward movement of the smoke plume leading up to the days of the exceptional event in New Jersey are represented in Figures 12 – 35.

Figure 13: Aerosol Optical Depth on May 19, 2016

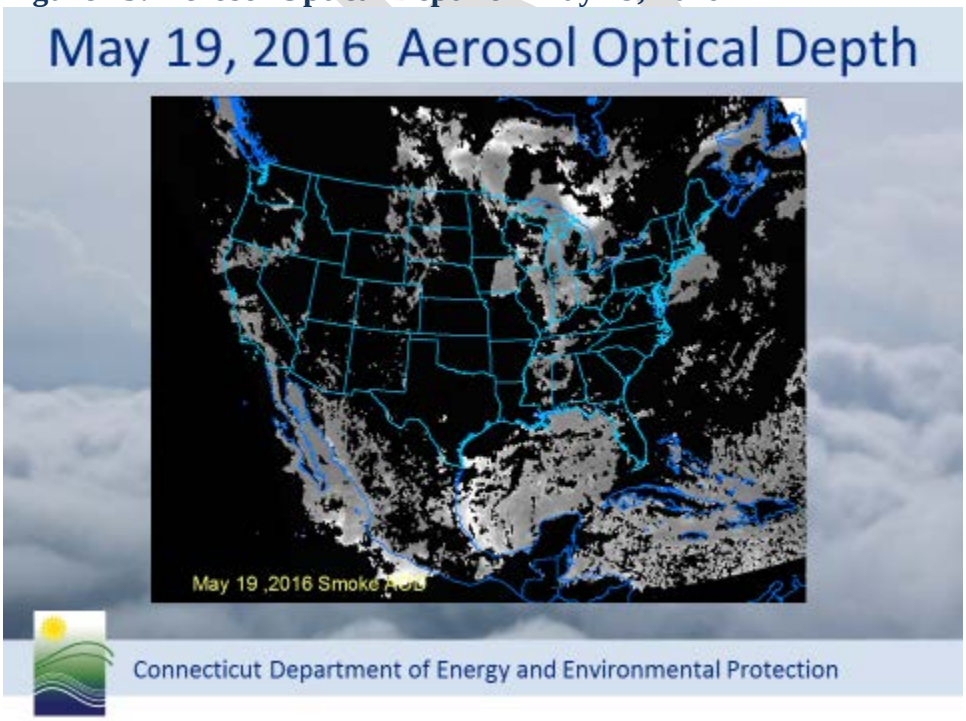


Figure 14: Patterns of Smoke and Fire Emissions on May 19, 2016

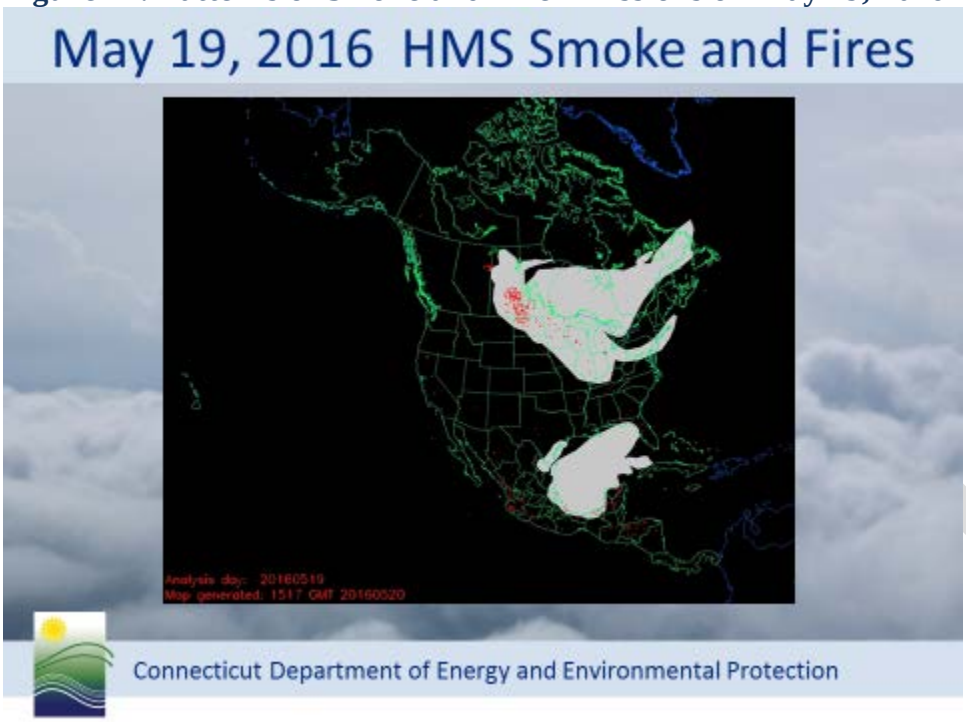


Figure 15: Trajectory of Wind on May 20, 2016

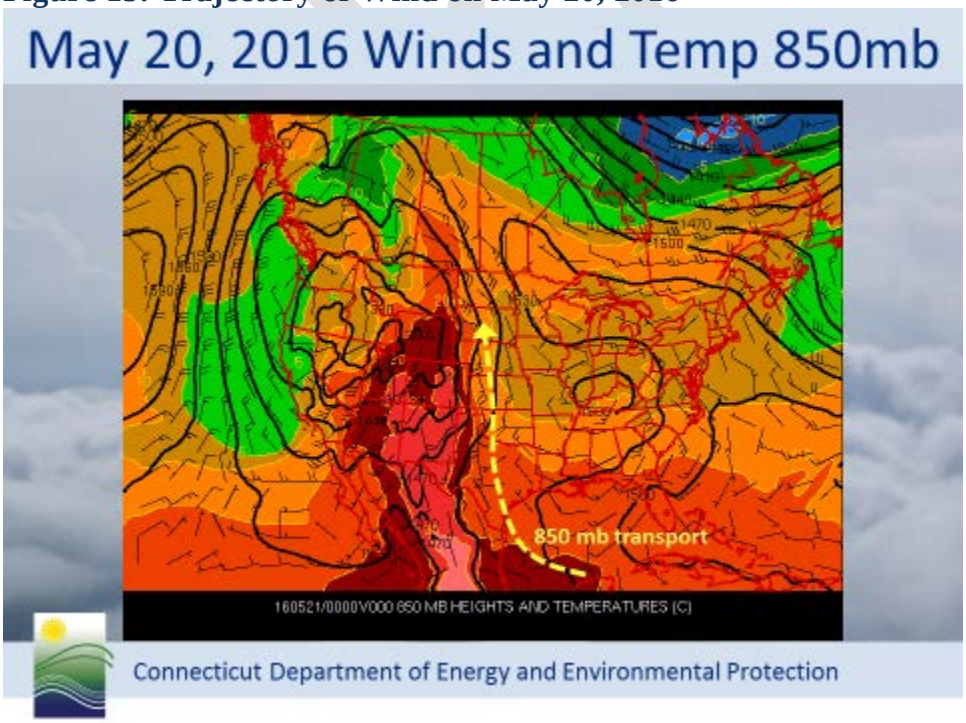


Figure 16: Aerosol Optical Depth on May 20, 2016

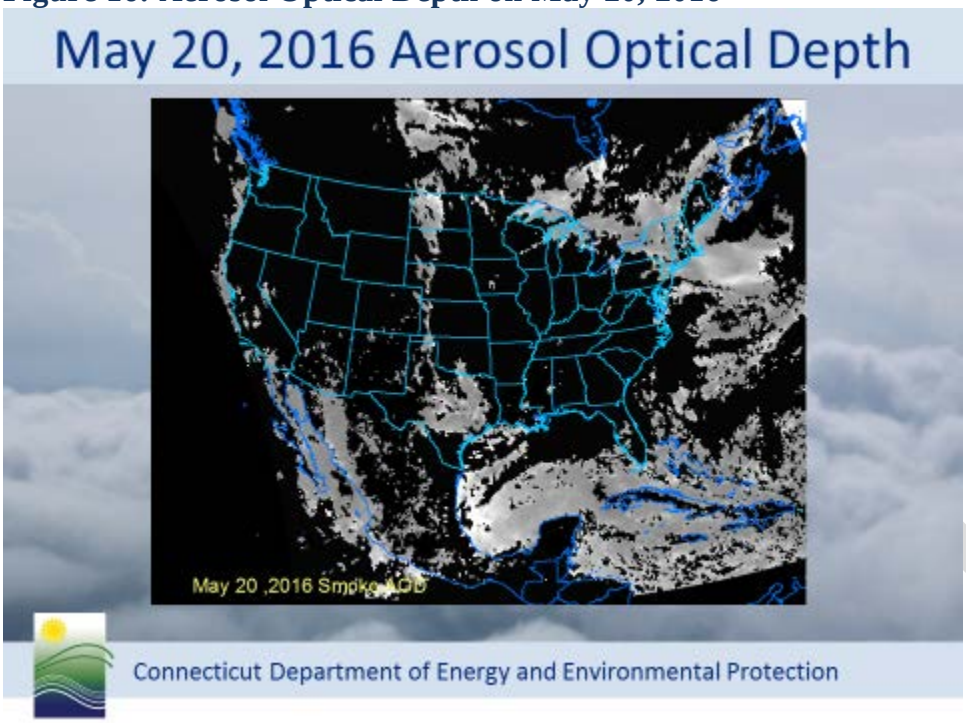


Figure 17: Patterns of Smoke and Fire Emissions on May 20, 2016

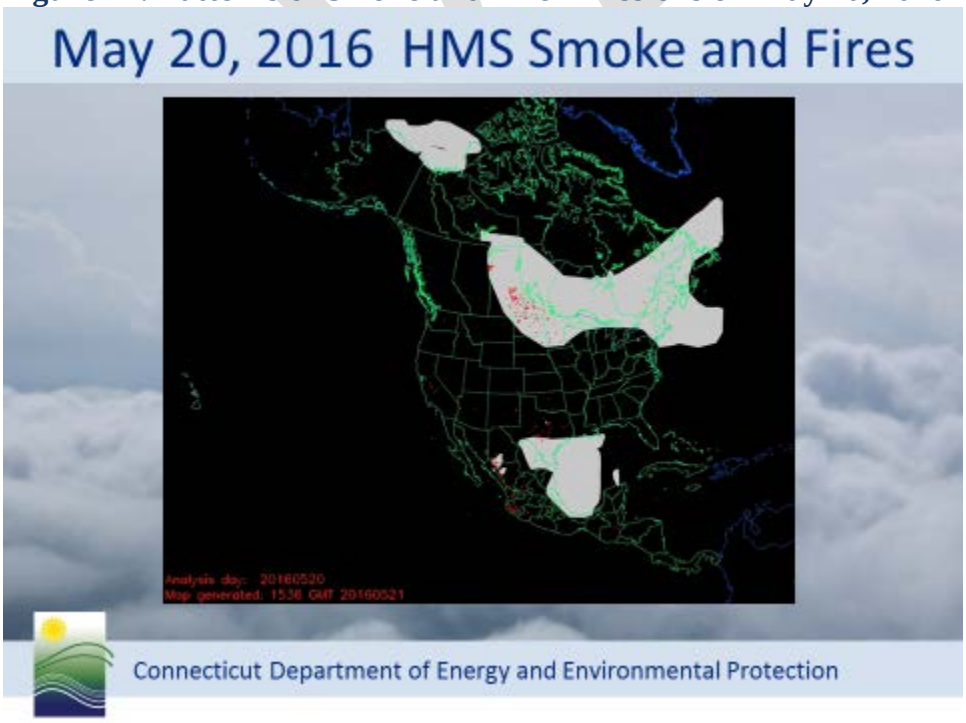


Figure 18: Trajectory of Wind on May 21, 2016

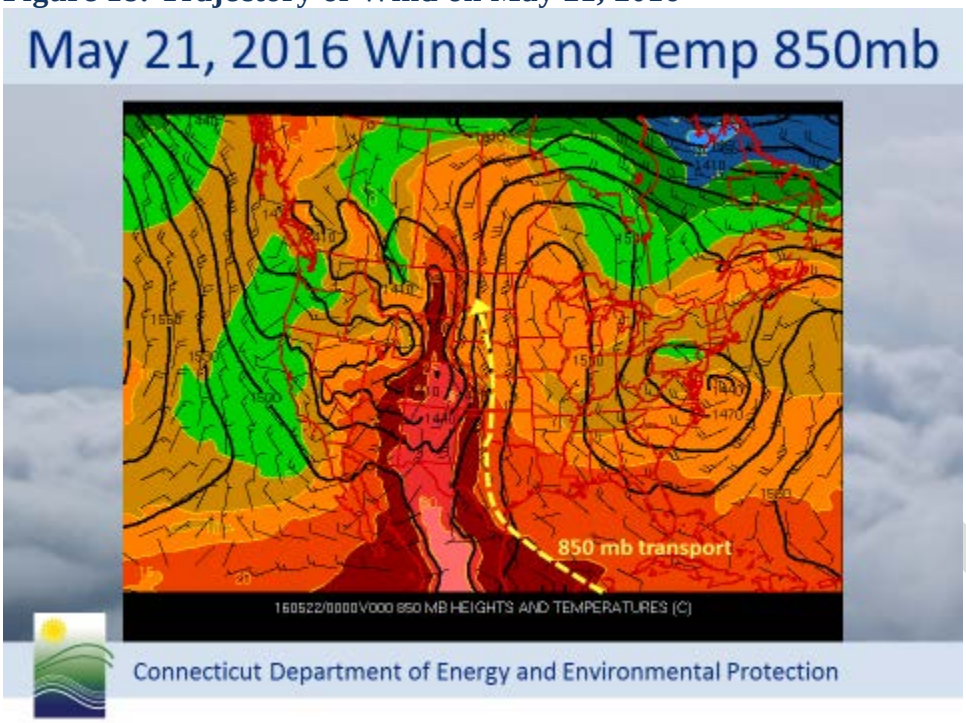


Figure 19: Aerosol Optical Depth on May 21, 2016

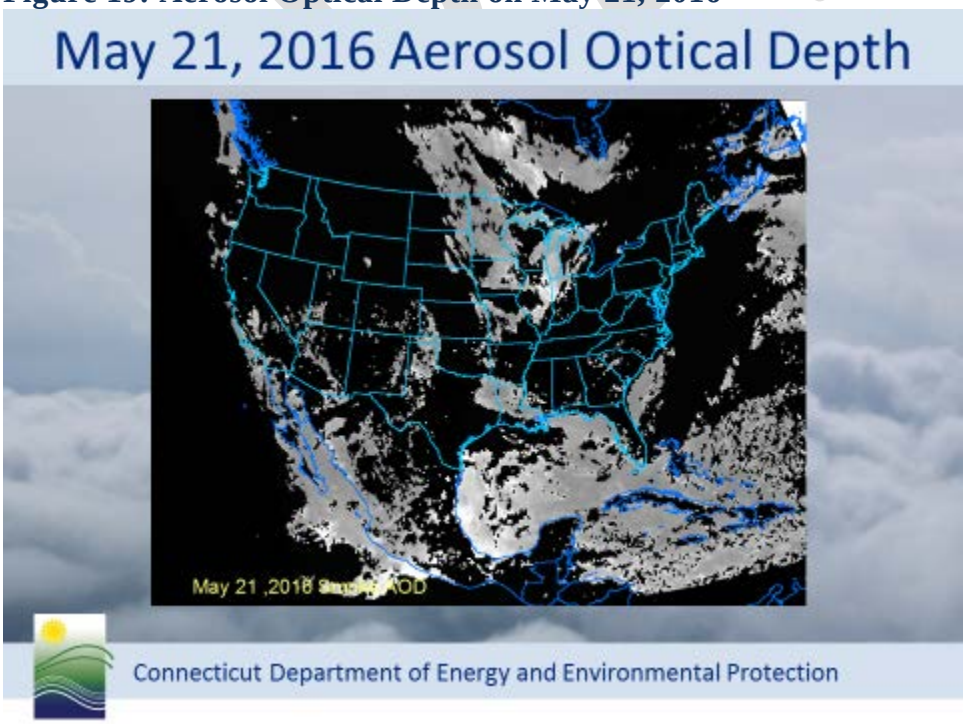


Figure 20: Patterns of Smoke and Fire Emissions on May 21, 2016

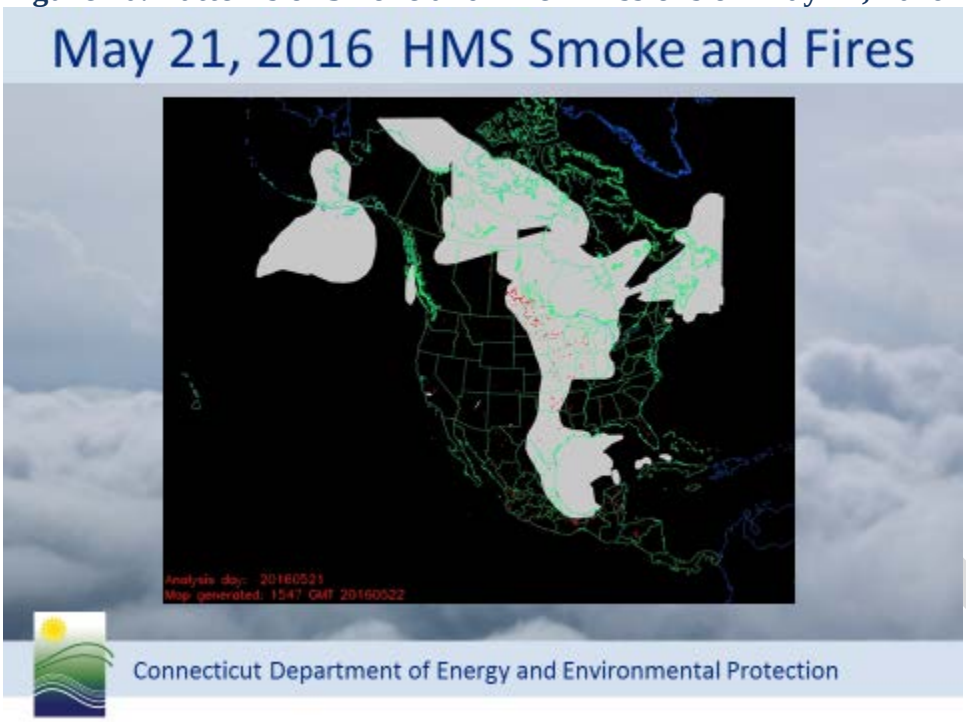


Figure 21: Trajectory of Wind on May 22, 2016

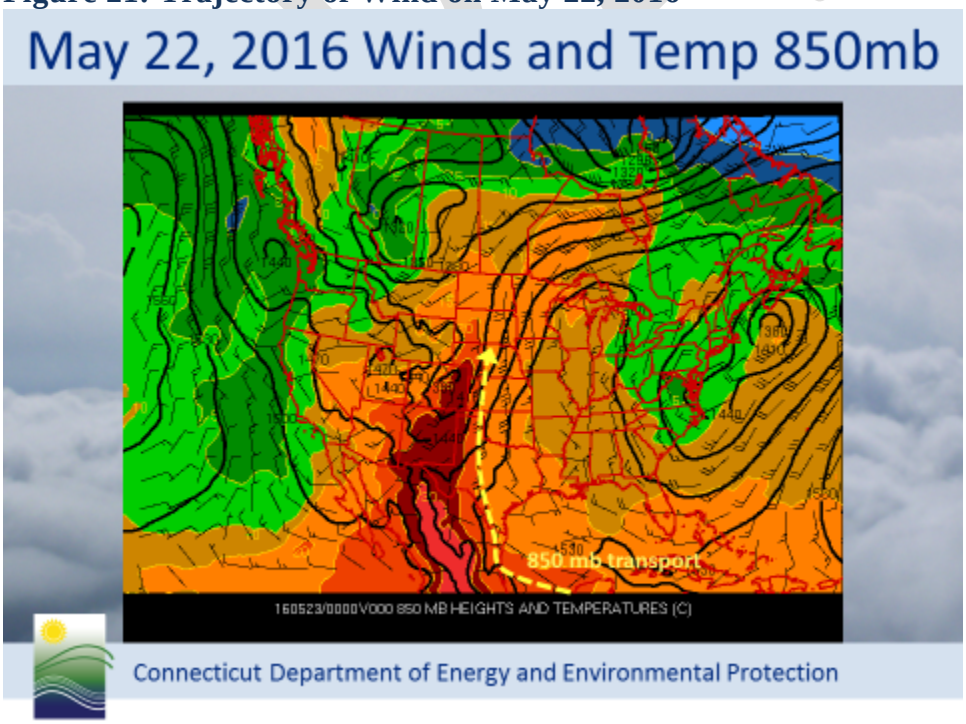


Figure 22: Aerosol Optical Depth on May 22, 2016

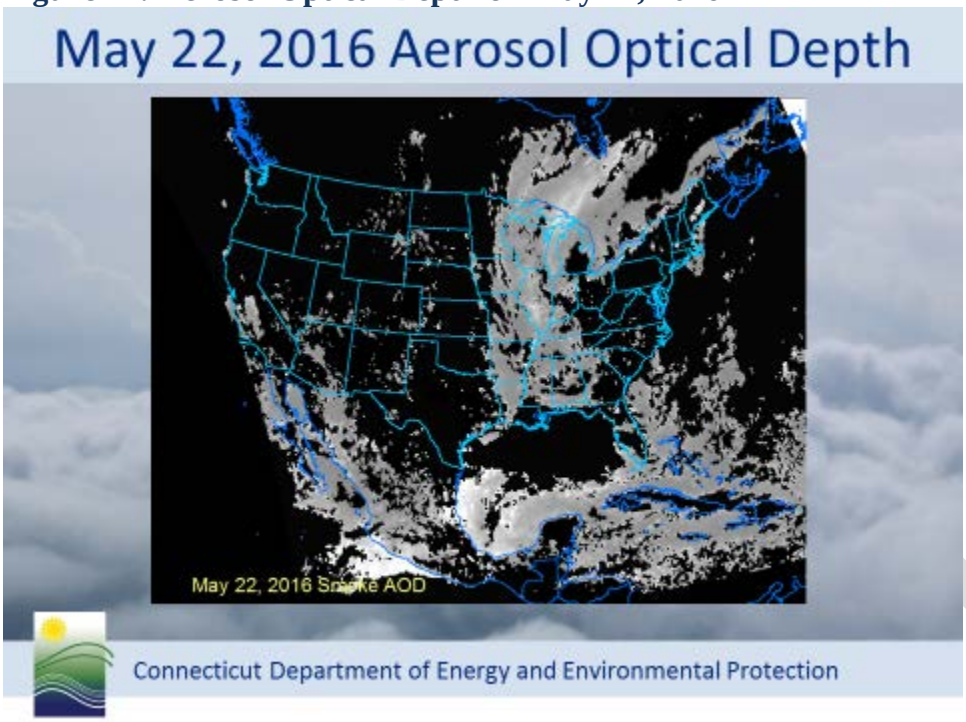


Figure 23: Patterns of Smoke and Fire Emissions on May 22, 2016

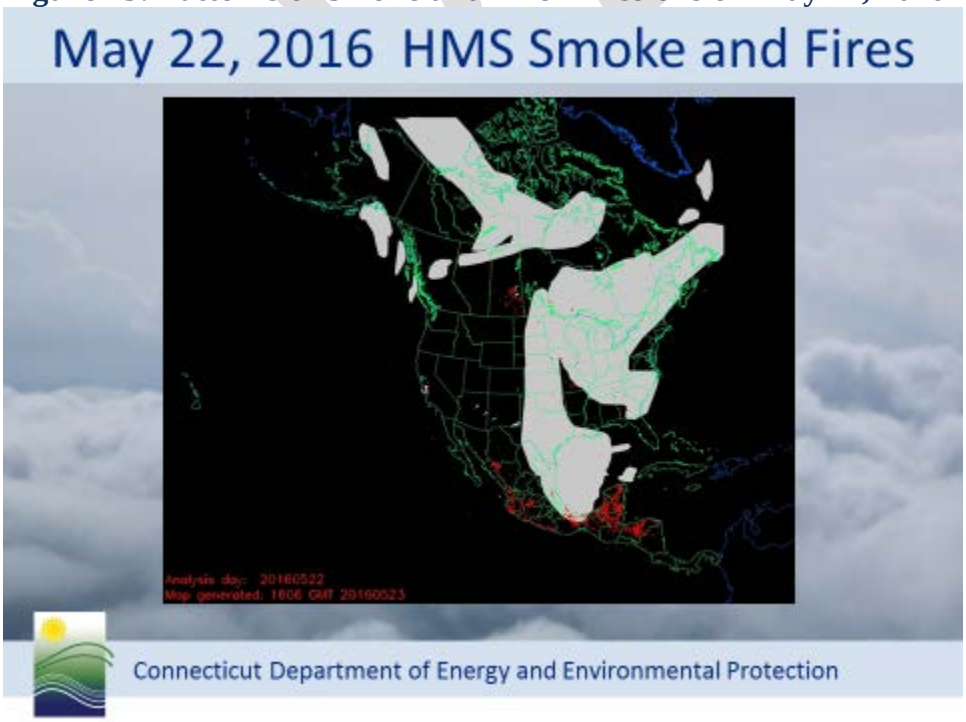


Figure 24: Trajectory of Wind on May 23, 2016

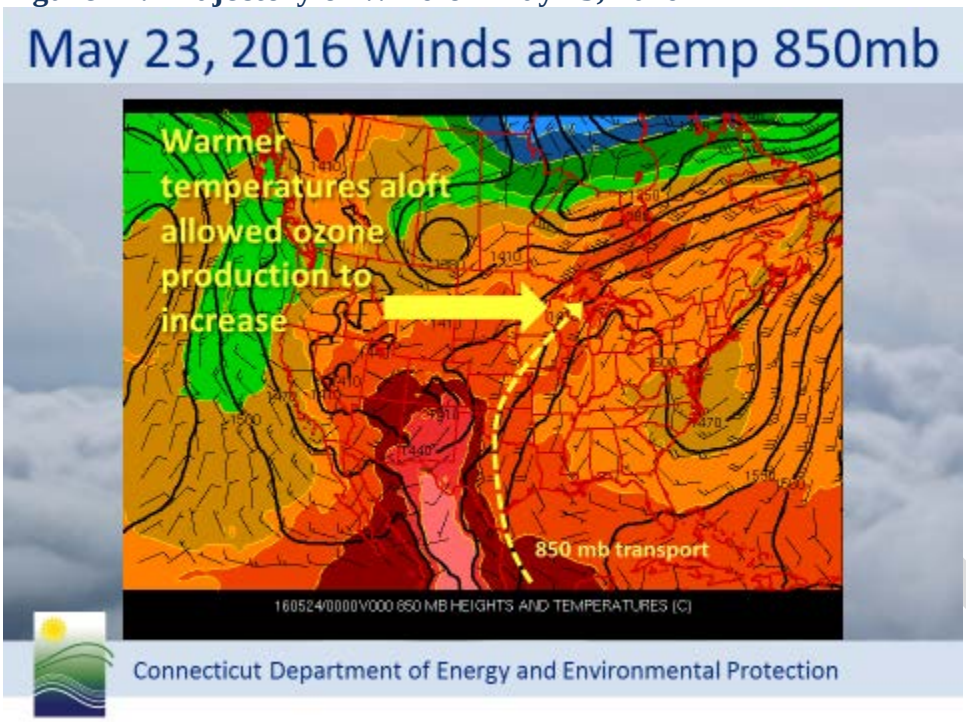


Figure 25: Aerosol Optical Depth on May 23, 2016

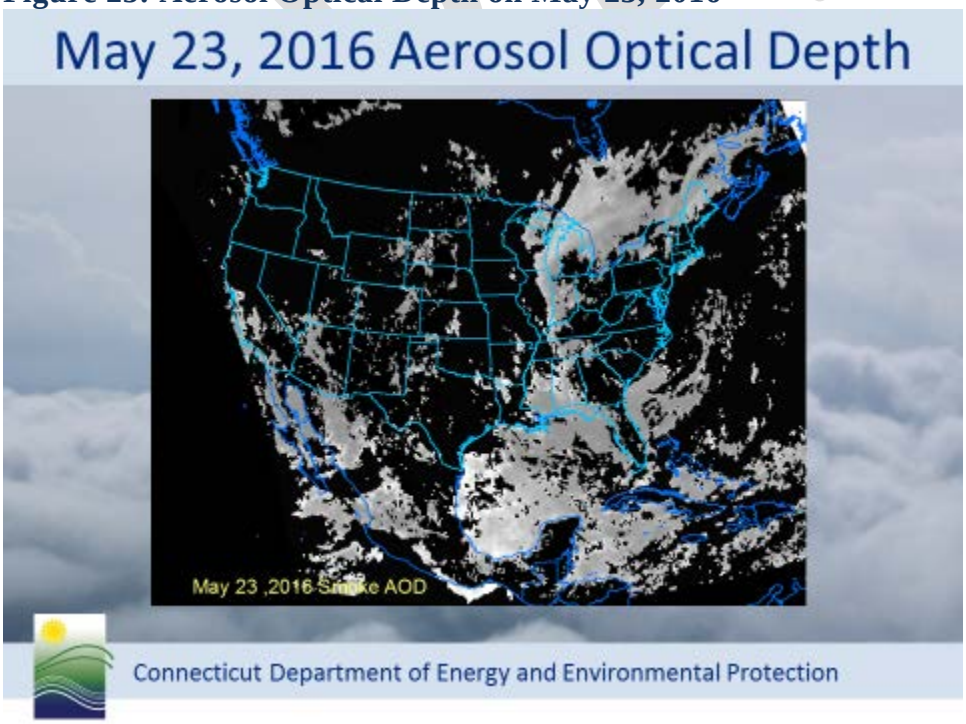


Figure 26: Patterns of Smoke and Fire Emissions on May 23, 2016

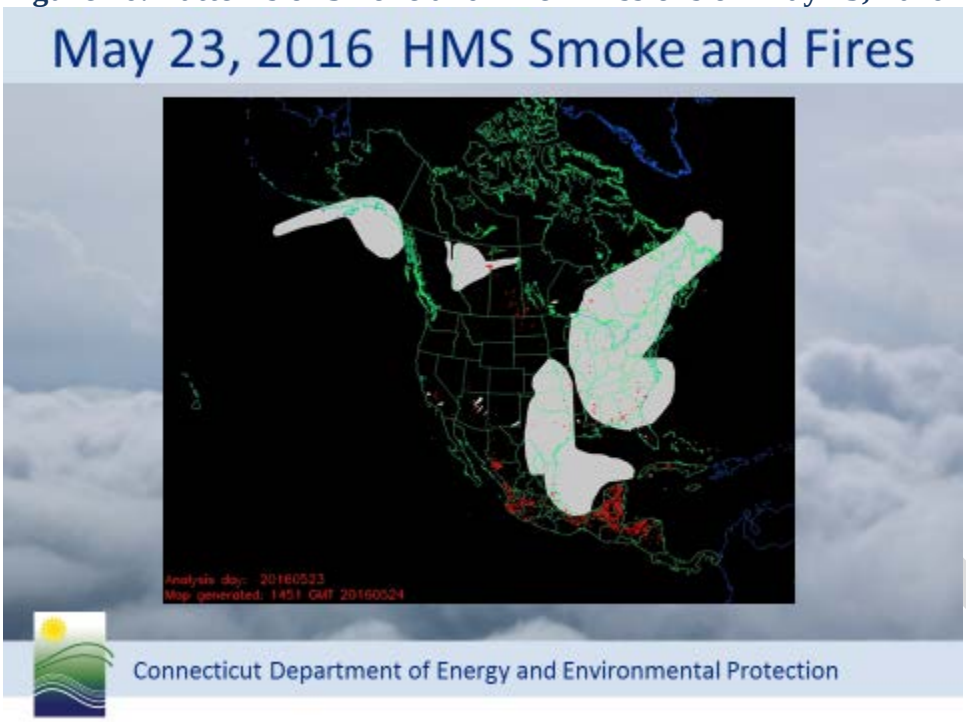


Figure 27: Trajectory of Wind on May 24, 2016

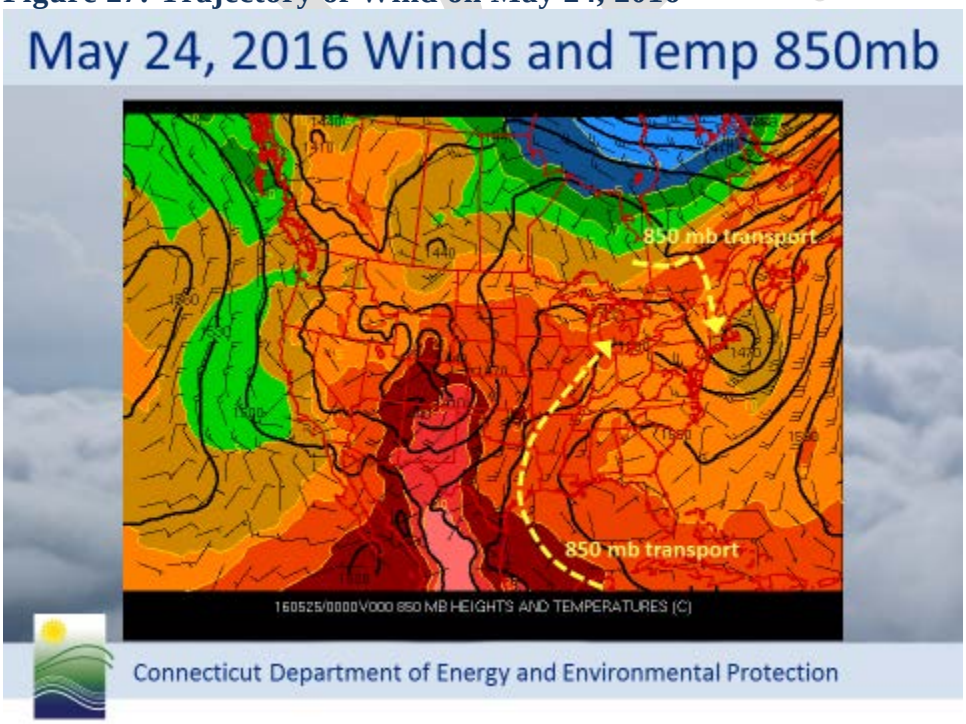


Figure 28: Aerosol Optical Depth on May 24, 2016

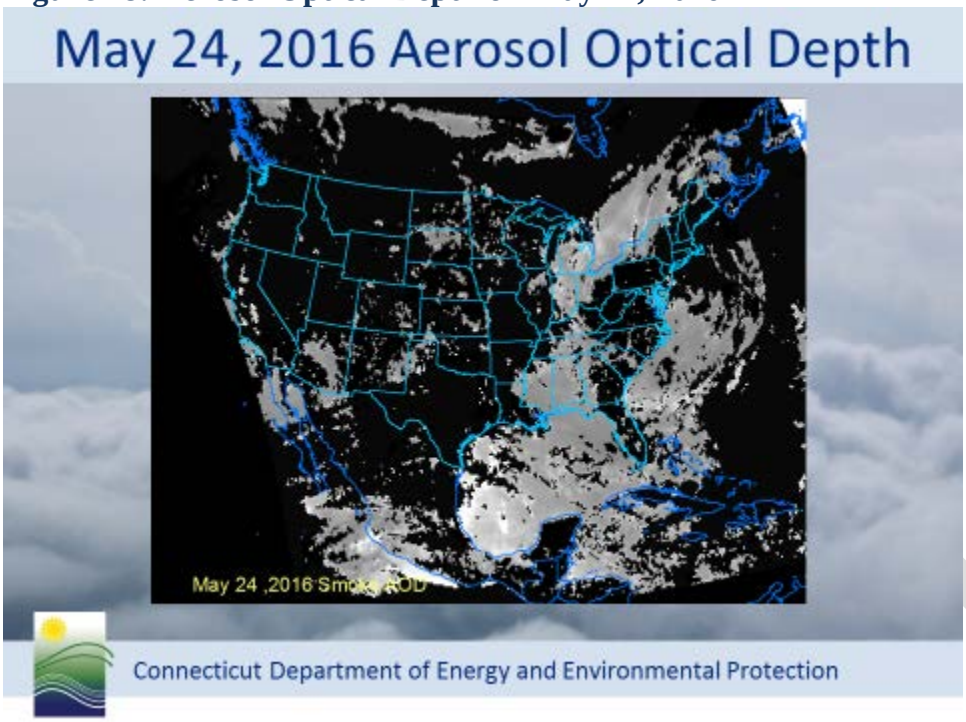


Figure 29: Patterns of Smoke and Fire Emissions on May 24, 2016

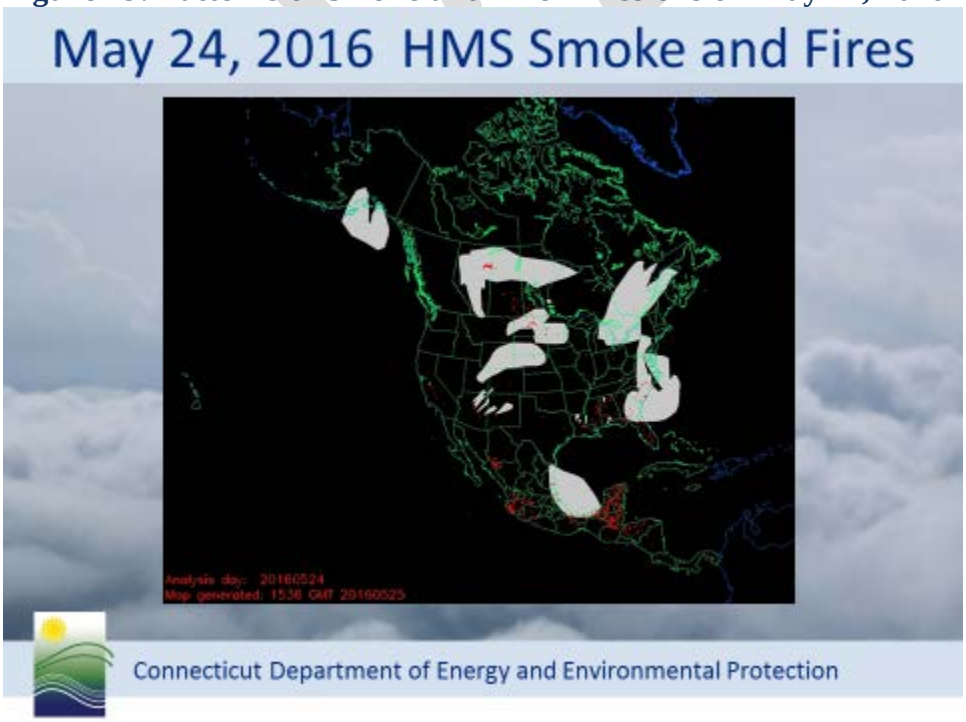


Figure 30: Trajectory of Wind on May 25, 2016

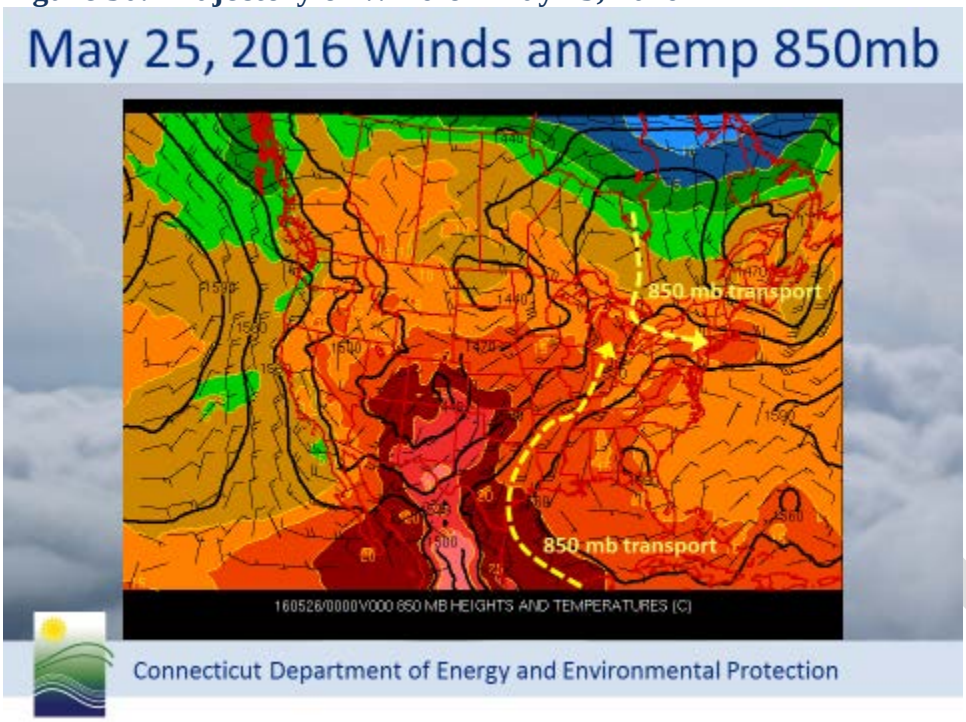


Figure 31: Aerosol Optical Depth on May 25, 2016 Showing Plume over New Jersey

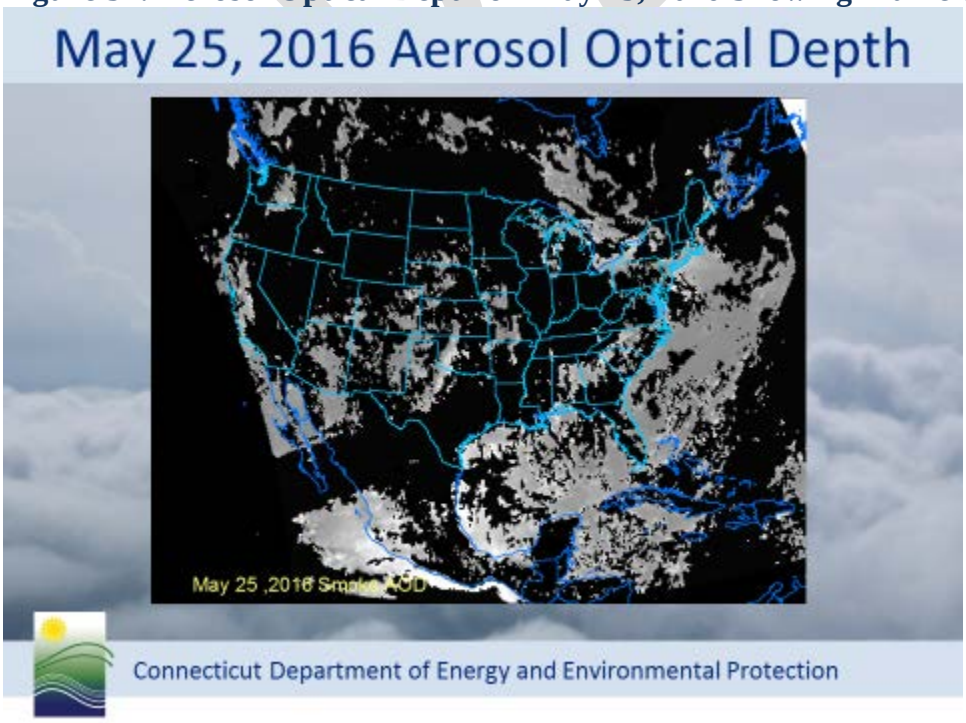


Figure 32: Patterns of Smoke and Fire Emissions on May 25, 2016

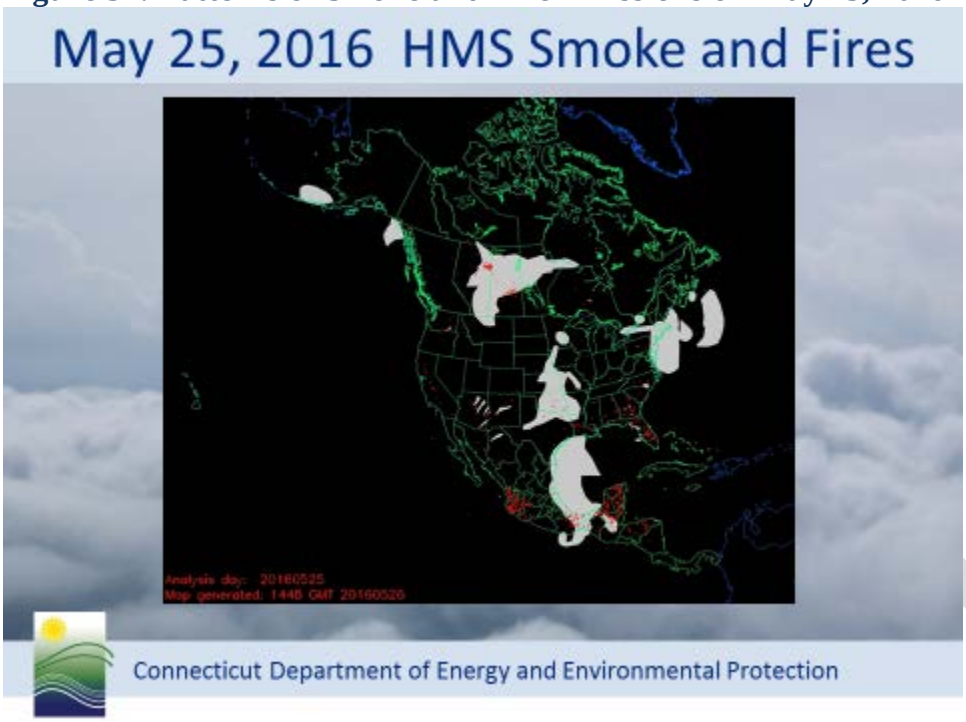


Figure 33: Trajectory of Wind on May 26, 2016

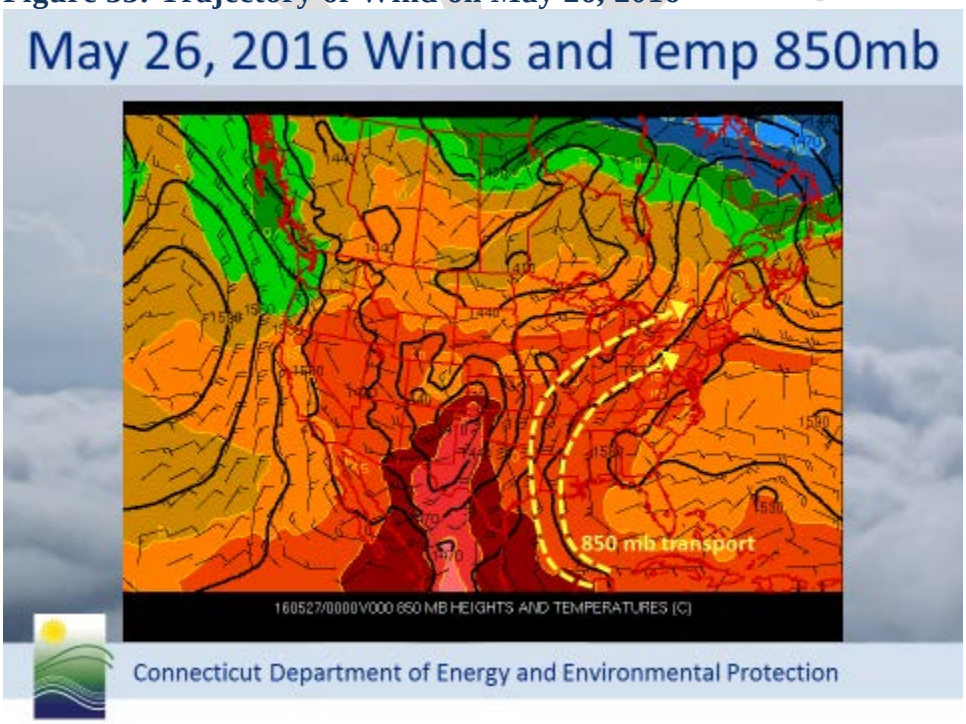


Figure 34: Aerosol Optical Depth on May 26, 2016 Showing Plume over New Jersey

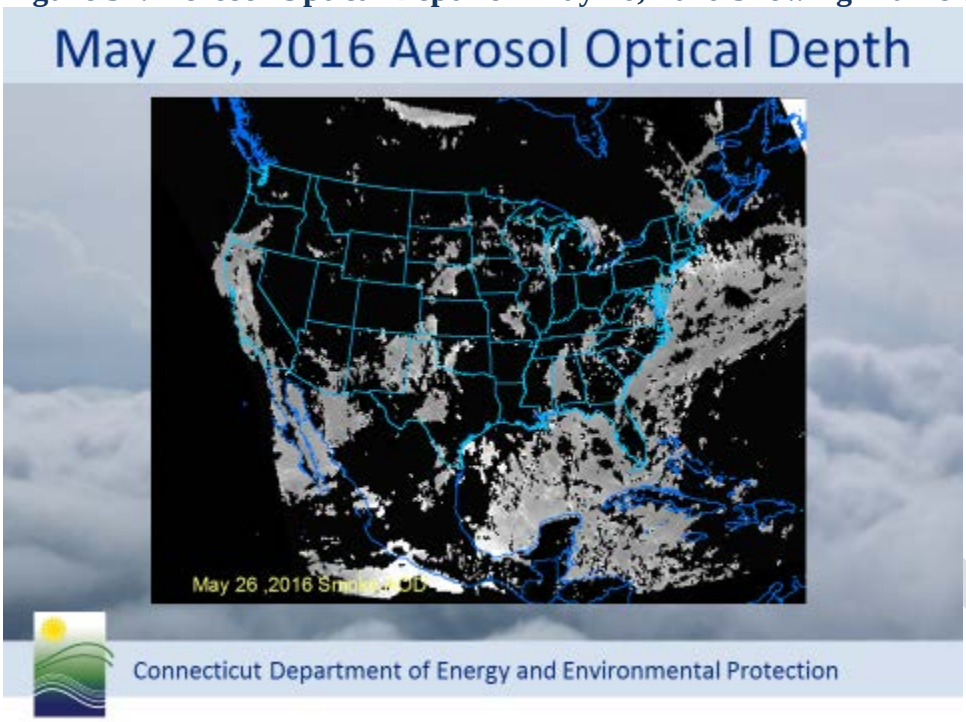
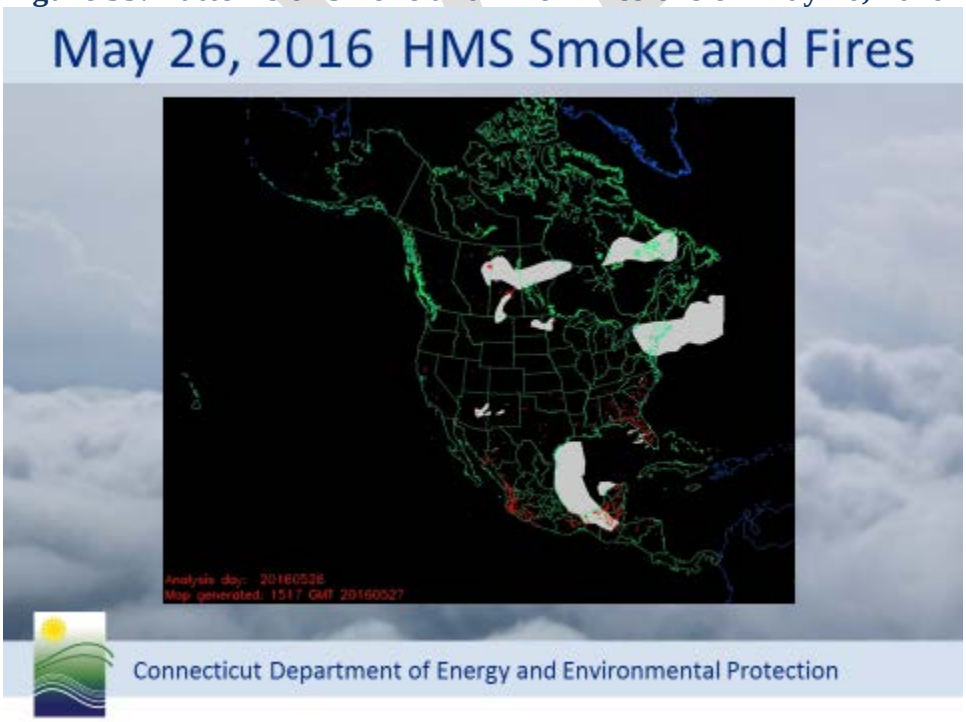


Figure 35: Patterns of Smoke and Fire Emissions on May 26, 2016



From May 19 – 26, 2016, smoke from Fort McMurray was transported into the upper Midwest, mixing with the residual smoke plume from the fires in Mexico. Ozone precursors were trapped in the atmospheric boundary layer to our west during the middle of May. Temperatures starting on May 23, 2016 were at levels conducive for ozone production. On May 25, 2016, the northwest flow of air aloft grabbed the residual plume and ozone from the Midwest and transported it to New Jersey. The result was elevated ozone levels in New Jersey on May 25 and 26, 2016.

5. Regulatory significance of data exclusion

The EPA allows states to exclude air quality monitoring data from use in determining exceedances or violations when that data was influenced by exceptional events. According to 40 CFR 50.1(j), the definition of an "exceptional event" means "an event(s) and its resulting emissions that affect air quality in such a way that there exists a clear causal relationship between the specific event(s) and the monitored exceedance(s) or violation(s), is not reasonably controllable or preventable, is an event(s) caused by human activity that is unlikely to recur at a particular location or a natural event(s), and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event."

The exclusion of ozone levels on the days of the exceptional event would have an impact on the calculation to determine if New Jersey and the surrounding region are attaining the ozone NAAQS. The Flemington, New Jersey monitor site would attain the 70 ppb ozone NAAQS in the northern nonattainment area and attainment in the southern area would be closer to the ozone NAAQS. Tables 1 and 2 show the ozone design values and the ppb change in the design value in New Jersey, and in the states that share New Jersey's nonattainment areas, if the monitored ozone data from the days of the exceptional event were excluded. The column for the Exceptional Event Design Value (EE DV) is the Design Value at the monitor if the data from the Canadian wildfire event were excluded from the calculation of the design value for the site. From a nonattainment perspective, the EE DV for the Northern NJ-NY-CT would reach attainment since the Westport, CT monitor would be recalculated to 82 ppb. Since the design value is calculated as the 3-year average of the annual 4th-highest daily maximum 8-hour ozone concentration, then the exclusion of the data will not only affect the 2016 DV calculation, but also the future DV calculations for 2017 and 2018 compliance with the NAAQS.

Table 1: Adjusted Design Values for the May, 2016 Exceptional Event Northern New Jersey Nonattainment Area[17]

State	Site Name	Prelim 2016	EE DV	Δ ppb
CT	Criscuolo Park	76	76	0
CT	Danbury	78	77	1
CT	Greenwich	81	80	1
CT	Madison-Beach Rd	76	76	0
CT	Middletown	79	79	0
CT	Stratford	81	80	1
CT	Westport	85	83	2
NJ	Bayonne	72	72	0
NJ	Chester	69	68	1
NJ	Columbia	64	63	1
NJ	Flemington	72	70	2
NJ	Leonia	74	74	0
NJ	Monmouth University	70	69	1
NJ	Newark Firehouse	70	70	0
NJ	Ramapo	69	68	1
NJ	Rutgers University	74	74	0
NY	Babylon	72	71	1
NY	Convent Av	69	68	1
NY	Holtsville	66	65	1
NY	IS52	67	67	0
NY	Pfizer Lab	70	70	0
NY	Queens	69	69	0
NY	Riverhead	72	70	2
NY	South Mountain Rd	72	71	1
NY	Susan Wagner	76	75	1
NY	White Plains	74	72	2

[17] Data can be obtained from https://www.epa.gov/outdoor-air-quality-data and is preliminary until all states have certified and quality assured the information.

Table 2: Adjusted Design Values for the May, 2016 Exceptional Event Southern New Jersey Nonattainment Area[18]

State	Site Name	Prelim. 2016	EE DV	Δ ppb
DE	Kent (KILLENS)	66	66	0
DE	New Castle (BCSP)	74	72	2
DE	New Castle (BELLFNT2)	70	70	0
DE	New Castle (LUMS 2)	68	68	0
DE	New Castle (MLK)	71	70	1
DE	Sussex (LEWES)	69	68	1
DE	Sussex (SEAFORD)	65	63	2
MD	Cecil (Fair Hill)	76	74	2
NJ	Ancora State Hospital	69	68	1
NJ	Brigantine	62	62	0
NJ	Camden Spruce St	75	74	1
NJ	Clarksboro	74	73	1
NJ	Colliers Mills	73	72	1
NJ	Millville	68	67	1
NJ	Rider University	72	71	1
NJ	Washington Crossing	73	73	0
PA	Bucks (BRIS)	77	76	1
PA	Chester (NEWG)	73	71	2
PA	Delaware (CHES)	72	72	0
PA	Montgomery (NORR)	72	70	2
PA	Philadelphia (LAB)	61	60	1
PA	Philadelphia (NEA)	77	76	1
PA	Philadelphia (NEW)	74	73	1

[18] Data can be obtained from https://www.epa.gov/outdoor-air-quality-data and is preliminary until all states have certified and quality assured the information.

II. Demonstration That the Event Affected Air Quality in Such a Way That There Exists a Clear Causal Relationship Between the Specific Event and the Monitored Exceedance or Violation

1. Comparison between ozone data requested for exclusion with historical concentrations

On Wednesday, May 25, 2016, sixteen (16) out of seventeen (17) monitors in New Jersey recorded exceedances of the 70 ppb 8-hour ozone NAAQS of 2015. The only station in New Jersey that did not exceed the new 70 ppb ozone NAAQS was Bayonne, with a concentration of 69 ppb. All sixteen stations also exceeded the 75 ppb 8-hour ozone NAAQS of 2008, and two stations exceeded the 84 ppb 8-hour ozone NAAQS of 1997. The highest 1-hour average ozone concentration recorded was 90 ppb at Colliers Mills.

On Thursday, May 26, 2016, ten exceedances were recorded in New Jersey of the 70 ppb 8-hour average ozone NAAQS of 2015. Nine stations also exceeded the 75 ppb 8-hour ozone NAAQS of 2008, and five stations exceeded the 84 ppb 8-hour ozone NAAQS of 1997. The highest 1-hour average ozone concentration recorded on May 26, 2016 was 88 ppb at the Flemington station. Table 3 summarizes the daily maximum 8-hour average ozone concentrations recorded in New Jersey from May 21, 2016 through May 29, 2016 with the exceedances highlighted.

Table 3: Daily Maximum Ozone Levels in New Jersey Before and After the Exceptional Event Days of May 25 and 26, 2016

Site Name	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29
Ancora State Hospital	39	42	49	47	76	64	61	54	33
Bayonne	38	47	51	36	69	76	54	68	47
Brigantine	53	49	53	49	79	62	52	45	21
Camden Spruce St	41	45	54	48	78	68	59	61	40
Chester	43	48	46	46	83	86	64	56	61
Clarksboro	37	44	56	55	83	70	59	58	36
Colliers Mills	43	52	59	57	90	70	66	62	40
Columbia	39	37	40	46	76	73	63	50	57
Flemington	41	46	49	53	83	88	69	69	61
Leonia	44	49	52	40	86	85	62	77	58
Millville	44	42	49	53	81	69	58	52	29
Monmouth University	46	51	53	45	81	65	49	50	37
Newark Firehouse	36	45	38	38	81	77	49	65	50
Ramapo	45	47	46	48	79	81	71	55	57
Rider University	41	41	48	54	82	82	67	70	55
Rutgers University	42	47	55	46	84	86	75	73	53
Washington Crossing*	33	44	51	55	83	86	74	74	57

*operated by EPA

exceeds 70 ppb NAAQS of 2015

exceeds 75 ppb NAAQS of 2008

exceeds 84 ppb NAAQS of 1997

The severity and widespread nature of this 2-day period was unusual and was not repeated in the rest of 2016. Sixteen out of 17 monitors recorded their highest daily maximum 8-hour average ozone concentrations for 2016 during this 2-day period. The next most severe ozone event occurred on July 22, 2016 where only seven monitors exceeded the NAAQS, and none exceeded 84 ppb, the ozone NAAQS of 1997. Table 4 compares the concentrations measured during this period with the 4 highest concentrations for the year. The shaded boxes show that the 1st maximum level for the year occurred on either May 25 or 26, 2016.

Table 4: O_3 Daily Max Values Compared With 4 Highest Daily Max in 2016

	Daily Max 8-Hr O_3 (ppb)		2016 Daily Maximum 8-Hr O_3 Concentrations (ppb)			
	5/25/2016	5/26/2016	1st Max	2nd Max	3rd Max	4th Max
Ancora State Hospital	76	64	76	76	69	69
Bayonne	69	76	76	74	69	69
Brigantine	79	62	79	68	67	63
Camden Spruce St	78	68	81	78	78	78
Chester	83	86	86	83	72	69
Clarksboro	83	70	83	79	77	76
Colliers Mills	90	70	90	77	73	72
Columbia WMA	76	73	76	73	72	66
Flemington	83	88	88	83	78	78
Leonia	86	85	86	85	77	75
Millville	81	69	81	70	69	69
Monmouth Univ	81	65	81	73	72	70
Newark Firehouse	81	77	81	77	71	70
Ramapo	79	81	81	79	79	72
Rider Univ	82	82	82	82	76	74
Rutgers Univ	84	86	86	84	78	76
Washington Crossing*	83	86	86	83	75	74

*Site is operated by the EPA.

2. Wildfire emissions were transported to the monitors

The increased ozone concentrations due to the transport of wood smoke from the Fort McMurray wildfires can be followed spatially and temporally by looking at the daily maximum 8-hour average ozone concentrations from selected sites over the three days before increased ozone levels were measured in New Jersey. Table 5 shows the maximum 8-hour ozone levels on May 25, the first day that elevated ozone levels were observed in New Jersey, and the four days prior to that day. Maps showing this progression of ozone in the plume across the Midwest to the eastern U.S. are shown in Figures 36 – 39. High ozone levels were experienced on May 23 and 24, 2016 in Wisconsin, Michigan, Indiana and Illinois. As the plume moved eastward, higher ozone levels were experienced in Ohio, Pennsylvania and New Jersey on May 25, 2016.

Table 5: Progressing Daily Maximum 8-Hour O_3 Concentrations From May 22 to 25, 2016 at Selected Stations in ppb Where the States are Ordered From West to East[19]

STATE	STATION	5/22/2016	5/23/2016	5/24/2016	5/25/2016
Wisconsin	Chiwaukee	55*	75	86	73
Wisconsin	Eau Claire	64	60	57	49
Wisconsin	Lake DuBay	59	68	51	46
Wisconsin	Newport	50	73	72	44
Michigan	Ann Arbor	56	76	77	66
Michigan	Grand Rapids	57	71	81	65
Michigan	Houghton Lake	62	64	74	64
Michigan	Lansing	51	67	76	65
Illinois	Braidwood	64	64	72	53
Illinois	Northbrook	58	71	79	64
Illinois	Jerseyville	65	75	62	51
Indiana	Albany	56	63	75	61
Indiana	Flora	57	69	71	58
Indiana	Indianapolis	62	72	74	61
Indiana	South Bend	54	69	74	64
Ohio	East Lake	49	49	76	82
Ohio	Kinsman	51	46	75	80
Ohio	Lebanon	61	58	79	63
Ohio	Lima	58	57	77	65
Pennsylvania	Erie	56	56	70	79
Pennsylvania	Lancaster	41	45	59	81
Pennsylvania	Moshamon	43	46	63	76
Pennsylvania	Peckville	32	44	63	79
New York	Pinnacle	46	49	73	77
New York	White Plains	52	56	38	82
New York	Whiteface	51	60	69	74
New York	Williamson	41	44	78	81
New Jersey	Brigantine	49	53	49	79
New Jersey	Colliers Mills	52	59	57	90
New Jersey	Leonia	49	52	40	86

*data from Harrington station

[19]This data of actual ozone levels in the middle of the United States from May 22 to May 25, 2016 were taken from the EPA's Airnowtech website. Data can be obtained from https://www.airnowtech.org and is preliminary until all states have certified and quality assured the information.

Figure 36: Daily Maximum 8-Hour Average O_3 Concentrations on May 22, 2016

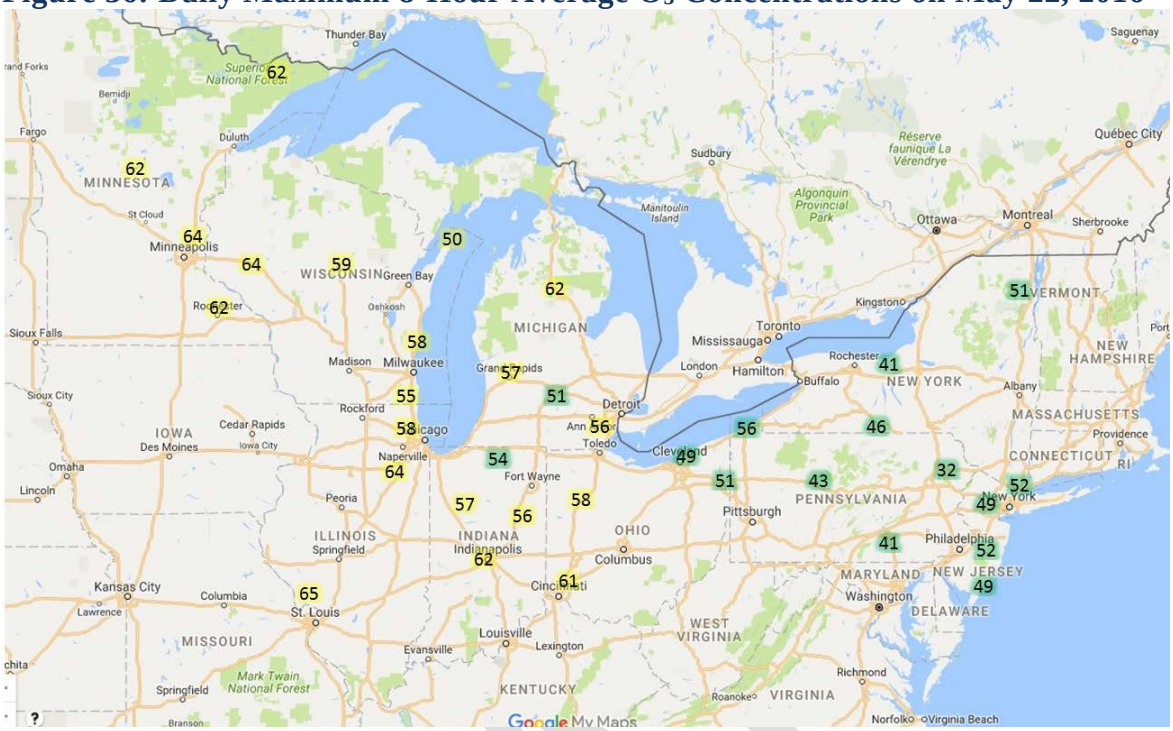


Figure 37: Daily Maximum 8-Hour Average O_3 Concentrations on May 23, 2016

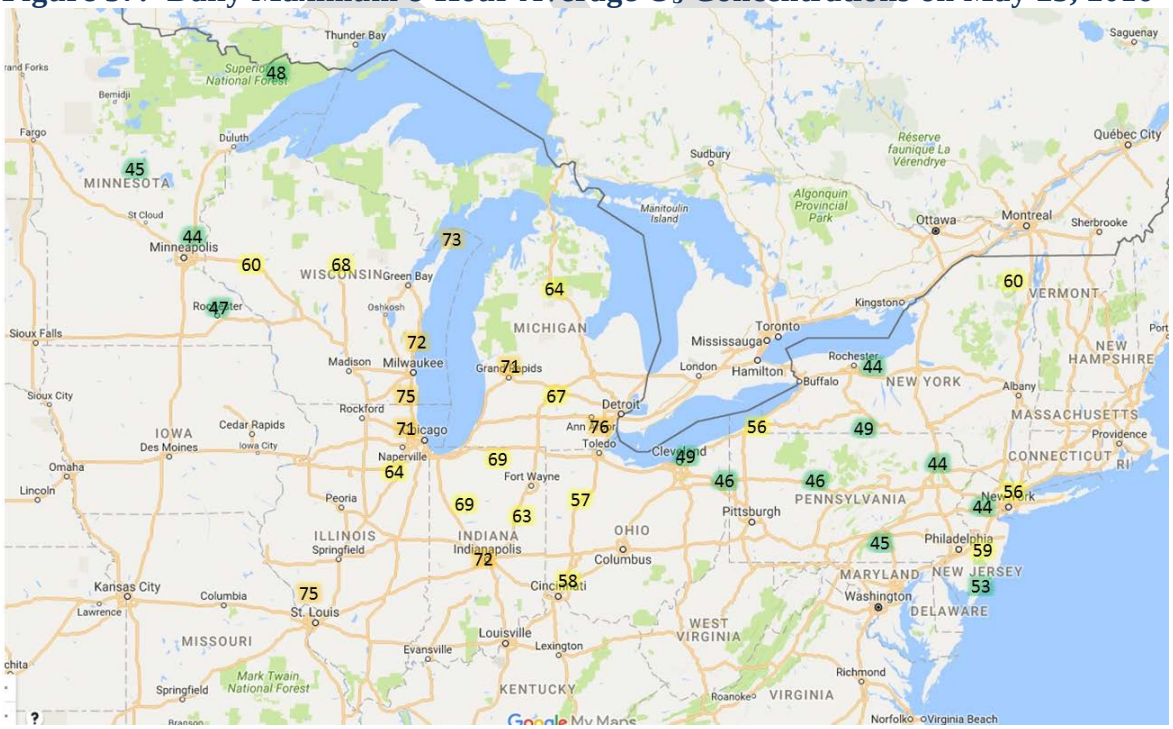


Figure 38: Daily Maximum 8-Hour Average O_3 Concentrations on May 24, 2016

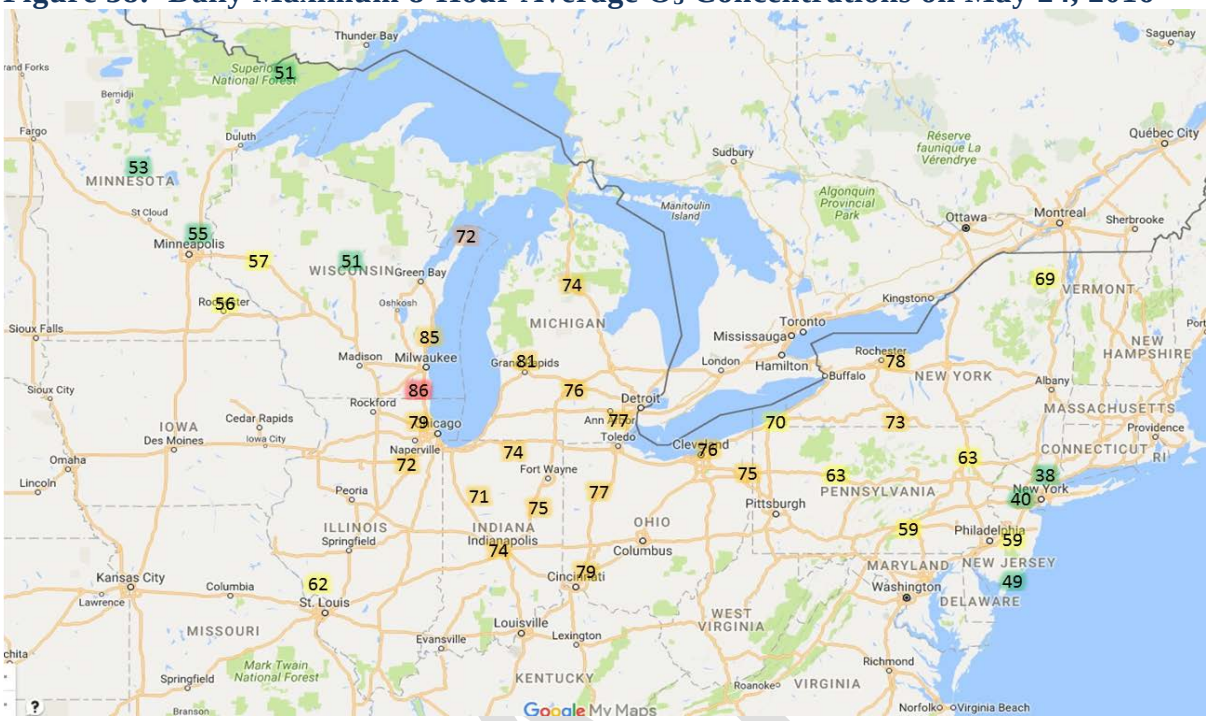
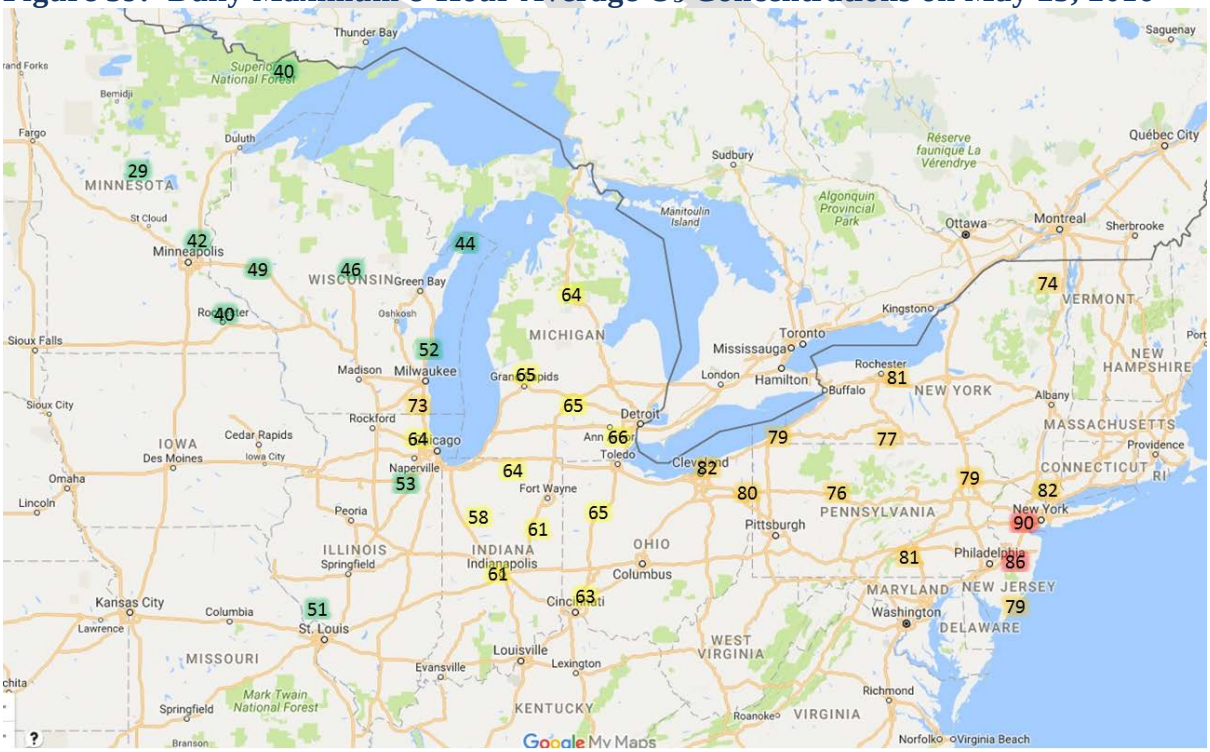


Figure 39: Daily Maximum 8-Hour Average O_3 Concentrations on May 25, 2016



III. Analyses Comparing the Claimed Event Influenced Concentrations to Concentrations at the Same Monitoring Site at Other Times

1. Similar days of meteorological conditions did not lead to high ozone levels in New Jersey when the wildfires were absent

New Jersey compared days when similar weather patterns existed to bring air from the area of the Fort McMurray wildfires during periods of time when the wildfire was not occurring. On these non-wildfire days of similar weather patterns, ozone levels in New Jersey are much lower when compared to the days of the exceptional event. The methodology to find similar days of meteorology as existed during the period of the exceptional event is as follows:

1. Analyze 12z & 0z sounding data from four different locations on May 25 and 26, 2016 to determine 850mb wind criteria;
2. Download soundings from various locations from the four-year period between May and June of 2012 to 2016;
3. Determine wind criteria (filter wind direction to the direction from where the Canadian wildfires were occurring): 295 – 330 degrees and had a wind speed greater than or equal to 20 knots for May 25, 2016 and a wind direction between 240 – 300 degrees and had a wind speed greater than or equal to 15 knots for May 26, 2016;
4. Run 24/48hr HYSPLIT back trajectories from 20z (4pm) for those days that fit the criteria; and,
5. Download Daily Ozone Air Quality Index (AQI) Maps for the exceptional event days.

The method New Jersey used to find similar meteorological days was to use upper air data in combination with surface data to filter out days that were meteorologically similar to the May 25 and 26, 2016 ozone event. First, sounding data from NOAA's Radiosonde Database was analyzed on May 25 and 26, 2016 to determine upper air wind criteria. Four years of 850mb sounding data was downloaded for May and June of 2012 – 2016 to compare against the event day data. The next step was to flag days meeting upper air criteria.

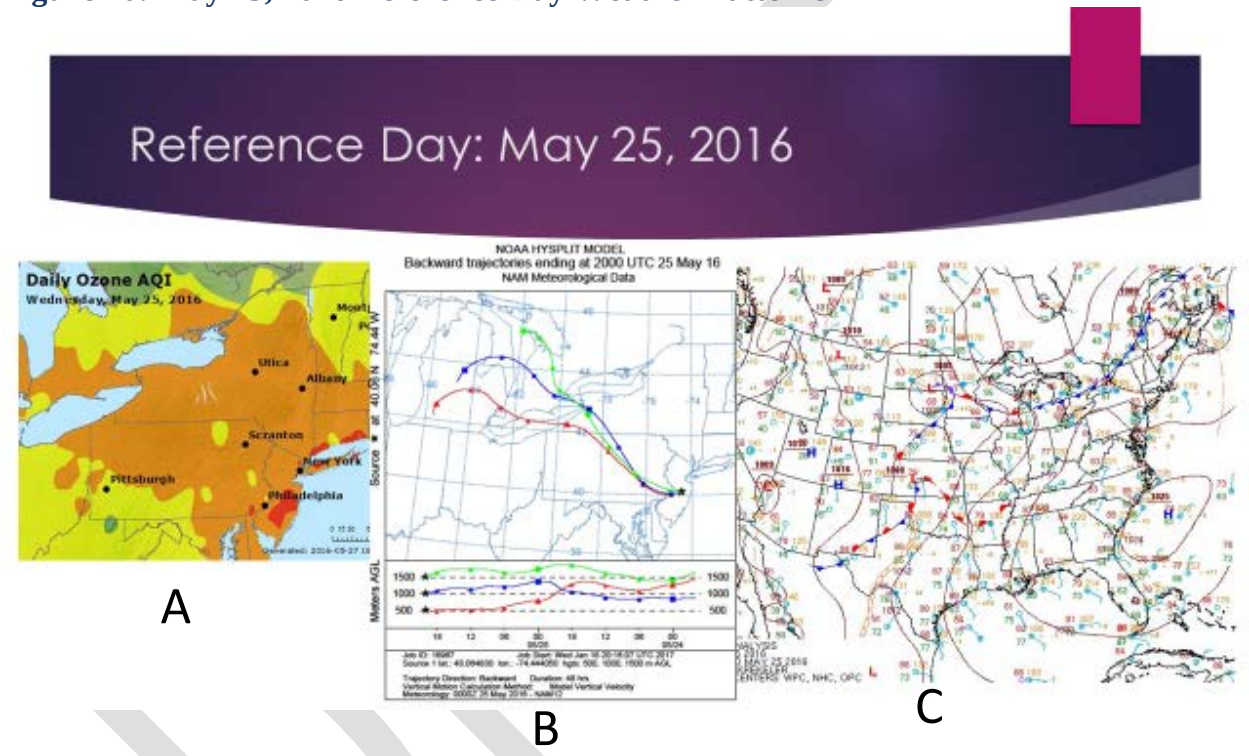
Once days were flagged with appropriate upper air criteria, the synoptic pattern on those days were reviewed by downloading the surface analysis from the National Weather Service's Weather Prediction Center. The HYSPLIT back trajectories and Daily Ozone AQI from AirNow.gov were also checked against those days before any days were considered similar. If all meteorological criteria and patterns were met, then that particular day was added to New Jersey's meteorological similar days for the analysis.

Similar Day Analysis - May 25th 2016

Using the method stated previously, the first part of this section will involve discussing similar meteorological days to May 25, 2016. The second part will consist of discussing similar days to May 26, 2016 due to different meteorological conditions present on each day. Figure 40 and Table 6 are the basis for which New Jersey based its similar day analysis for May 25, 2016. The AQI (Figure 40, picture A) for this day indicated widespread, unhealthy ozone air quality,

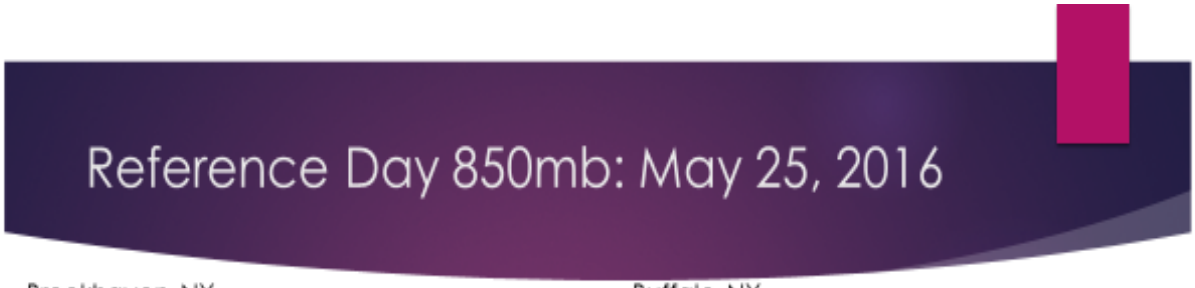
including New Jersey and its shared nonattainment areas. Upper air wind criteria for similar days to May 25th was determined to be: 295 – 330 degrees and greater than or equal to 20 knots for wind direction and wind speed as shown in Table 6. The synoptic pattern of interest was an approaching front from the northwest (Figure 40, picture C), trajectories from the northwest (Figure 40, picture B), and a strong high pressure system over the Atlantic Seaboard (Figure 40, picture C). The meteorological conditions previously stated will be shown in the similar day analysis in Figures 41 – 43. In the similar day analysis, good to moderate ozone levels were monitored in New Jersey when the weather patterns of interest were observed but wildfires in Alberta, Canada were not occurring.

Figure 40: May 25, 2016 Reference Day Weather Patterns



There is no upper air sounding station located in New Jersey to provide specific wind data for the analysis. The nearest four stations – Brookhaven, NY; Buffalo, NY; Pittsburgh, PA; and Albany, NY – were used to make an estimate on what New Jersey's 850mb wind conditions would have been on May 25, 2016. Based on reports from the nearest sounding stations, conditions for New Jersey would be very similar to the conditions in Table 6.

Table 6: Meteorological Conditions for May 25, 2016 as Determined by the Nearest Upper Air Stations



Brookhaven, NY

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	0	25	MAY	2016		
	4	850	1482	96	26	335	21
254	12	25	MAY	2016		
	4	850	1533	130	-30	315	22

Buffalo, NY

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	0	25	MAY	2016		
	4	850	1518	142	-8	300	18
254	12	25	MAY	2016		
	4	850	1542	146	36	270	20

Pittsburgh, PA

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	12	25	MAY	2016		
	4	850	1562	126	16	260	6
	4	850	1563	148	58	245	9

Albany NY

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	0	25	MAY	2016		
	4	850	1492	116	-4	330	15
254	12	25	MAY	2016		
	4	850	1527	146	-74	320	23

Figures 41 – 43 describe the similar days selected by New Jersey with each criterion presented for each day. Three similar days of meteorological conditions were found for May 25, 2016: July 23, 2016; June 22, 2015; and May 20, 2014. Figures 41 – 43 provide the data for each of the representative days respectively. The image in the top left shows ozone conditions present based on the AQI, and the image in the top right shows upper air sounding data. The HYSPLIT backward trajectory showing where winds originated is in the center and the surface analysis demonstrating synoptic patterns is on the bottom right. Each day in Figures 41 – 43 demonstrate similar meteorological conditions yet all days have clean ozone levels compared to May 25, 2016.

Figure 41: Similar Day 1: June 22, 2015

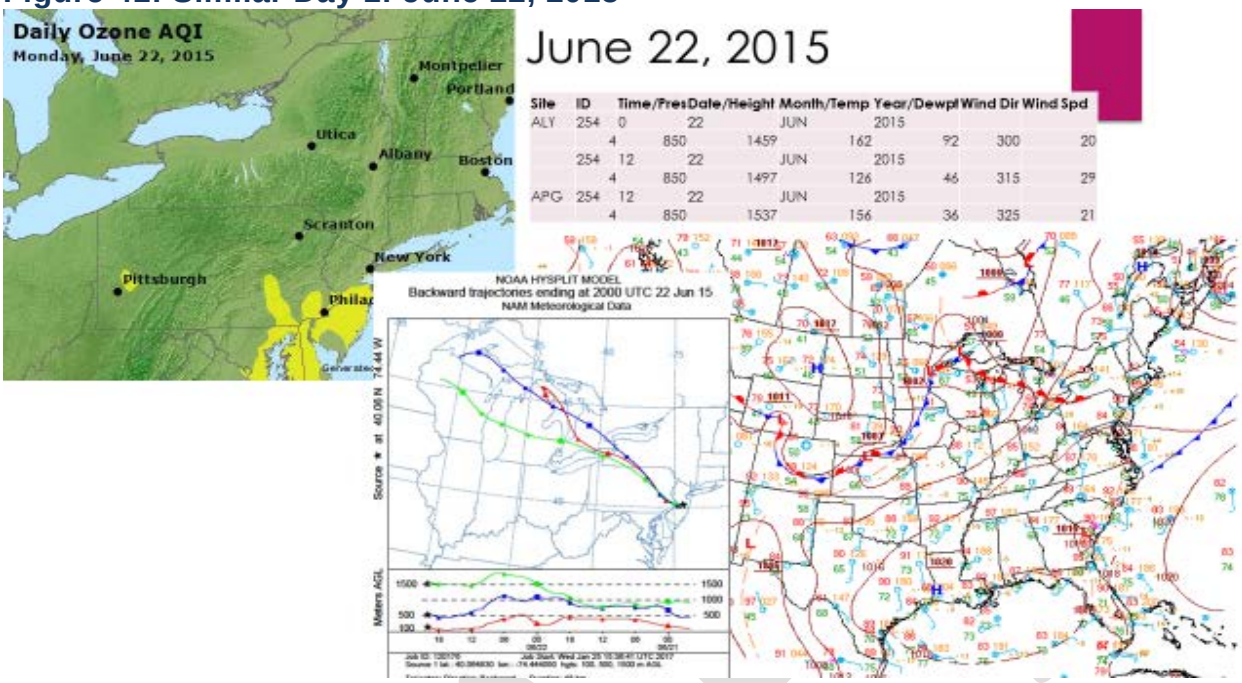


Figure 42: Similar Day 2: July 23, 2016

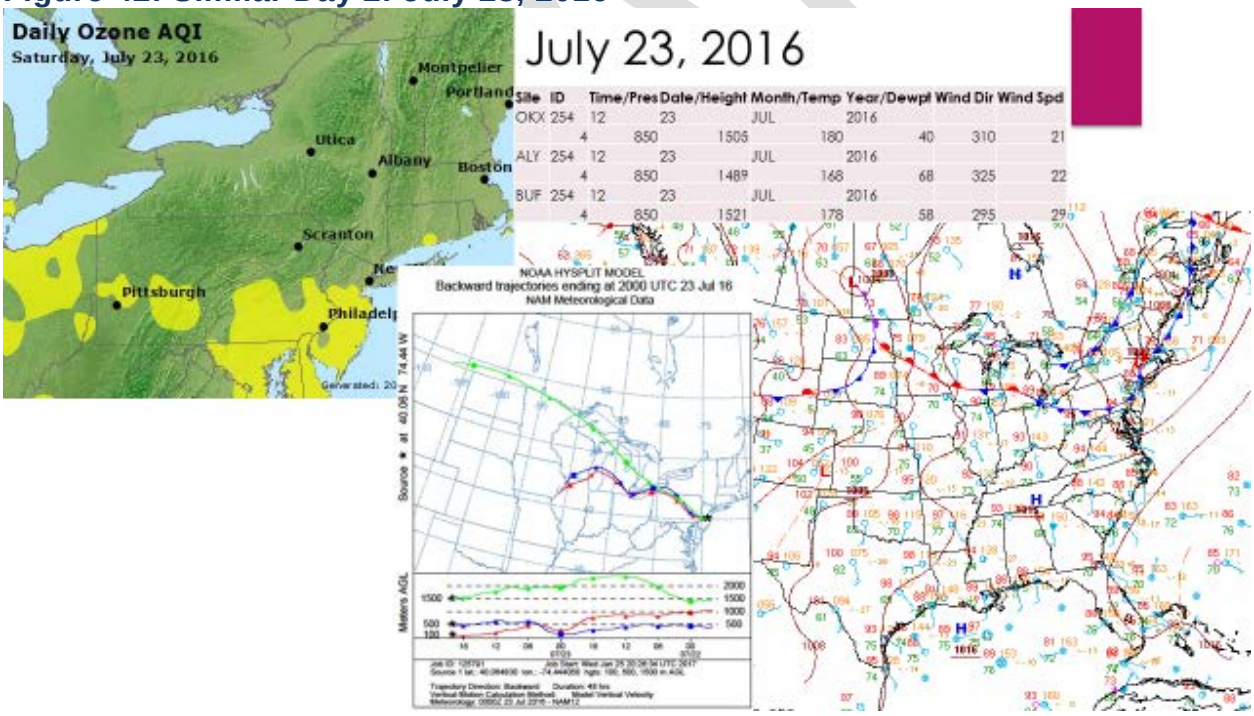
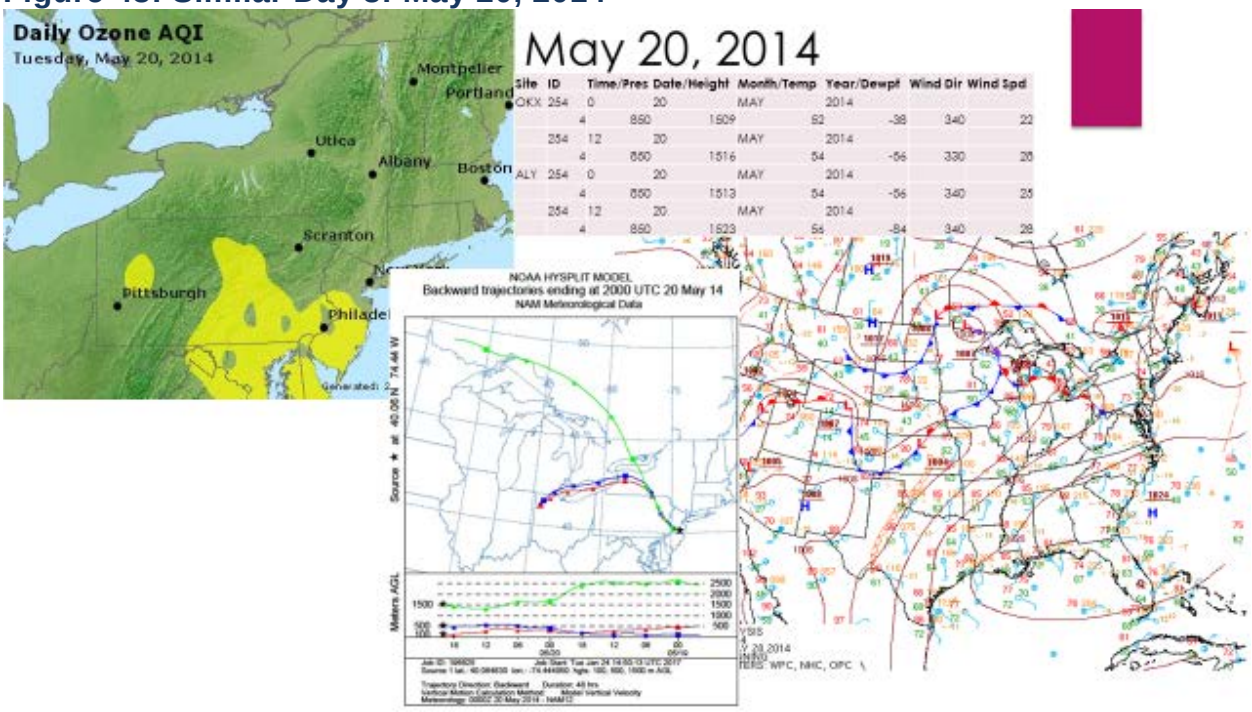


Figure 43: Similar Day 3: May 20, 2014



The Similar Day Analysis for May 26, 2016

Figure 44 represents the reference day conditions on May 26, 2016 and will be the basis for the similar day analysis for May 26, 2016. The AQI (Figure 44, picture A) for this day also indicated similar widespread, unhealthy ozone air quality, across New Jersey and its shared nonattainment areas, though not to the same extent as seen on May 25, 2016. The synoptic pattern investigated was an approaching front from the northwest (Figure 44 C), trajectories mostly from the west (Figure 44 B), and strong high pressure system over the Atlantic Seaboard with a surface low pressure trough over New Jersey (Figure 44 C).

Upper air wind criteria for similar days to May 26, 2016 was determined to be: 240 – 300 degrees and greater than or equal to 15 knots for wind direction and wind speed as shown in Table 7. As stated previously, there is no sounding station located in New Jersey. The nearest four stations – Brookhaven, NY; Buffalo, NY; Pittsburgh, PA; and Albany, NY – were used to make an estimate on what New Jersey's 850mb wind conditions would have been on May 26, 2016. Based on reports from the nearest surrounding stations, conditions for New Jersey would be very similar to those shown in Table 7.

Figure 44: May 26, 2016 Reference Day Weather Patterns

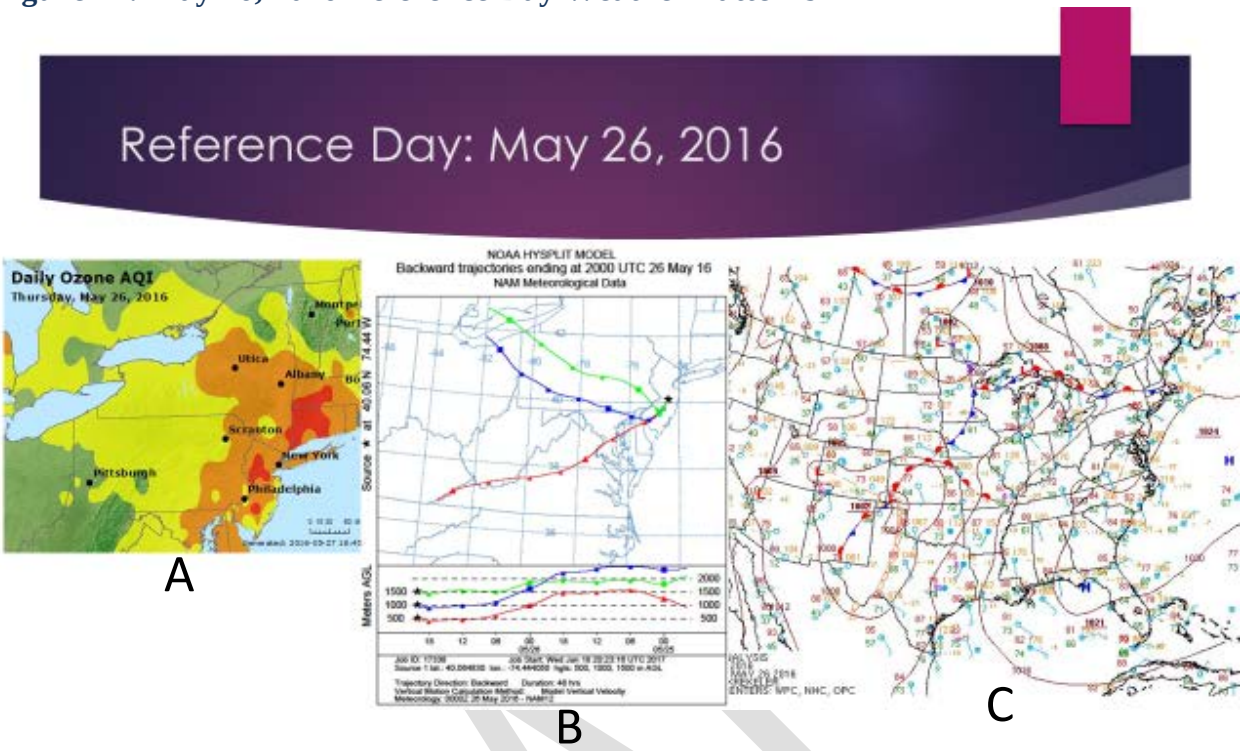
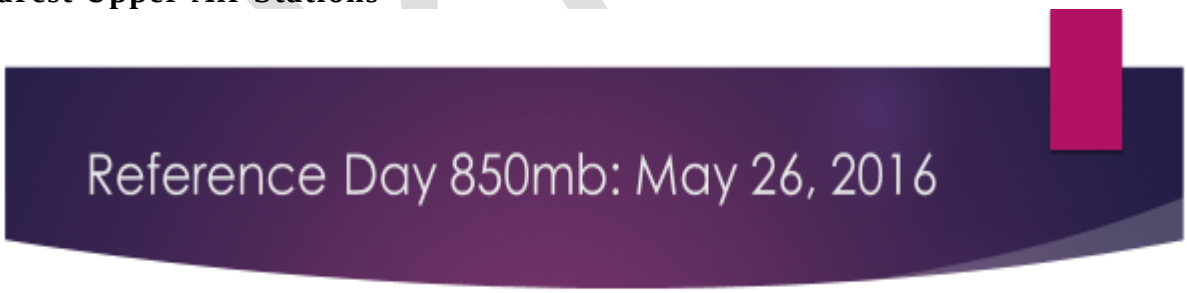


Table 7: Meteorological Conditions for May 26, 2016 as Determined by the Nearest Upper Air Stations



Brookhaven, NY

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	0	26	MAY	2016		
	4	850	1554	158	8	290	17
254	12	26	MAY	2016		
	4	850	1571	154	54	265	9

Buffalo, NY

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	0	26	MAY	2016		
	4	850	1551	152	32	255	19
254	12	26	MAY	2016		
	4	850	1545	138	68	220	15

Pittsburgh, PA

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	12	26	MAY	2016		
	4	850	1554	140	107	210	20
	4	850	1532	146	115	240	14

Albany NY

ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
254	12	26	MAY	2016		
	4	850	1562	148	58	290	23

The meteorological conditions listed previously will be shown in the similar day analysis in Figures 45 – 51. In the similar day analysis, good ozone levels were monitored for most of New Jersey when the weather patterns of interest were observed but wildfires in Alberta, Canada were not occurring.

Figures 45 – 51 describe the similar days selected by New Jersey with each criterion presented for each day. Seven similar days were found for May 26, 2016. The similar days selected are: May 16, 2015; May 17, 2015; June 16, 2015; May 12, 2014; June 16, 2013; June 17, 2013; and May 28, 2012. The images in Figures 45 – 51 describe the similar days selected by New Jersey with each criterion presented for each day. The image in the top left shows ozone conditions present. The HYSPLIT backward trajectory is in the center and the surface analysis is on the left.

Figures 45 –51 provide the data for each of the representative days respectively. The image in the top left shows ozone conditions present and the image in the bottom left shows upper air sounding data. The HYSPLIT backward trajectory showing where winds originated is in the center and the surface analysis demonstrating synoptic patterns is on the bottom right. Each day in Figures 45 – 51 demonstrate similar meteorological conditions yet all days have clean ozone levels compared to May 26, 2016

Figure 45: Similar Day 1: May 16, 2015

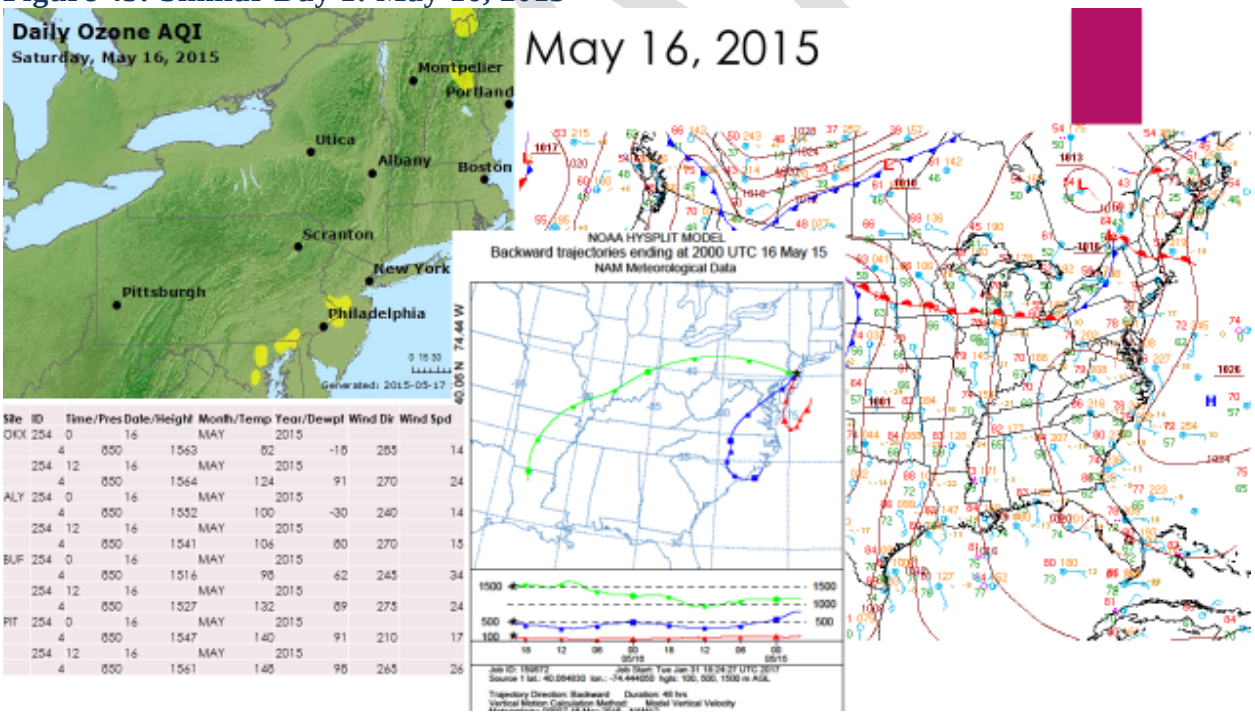
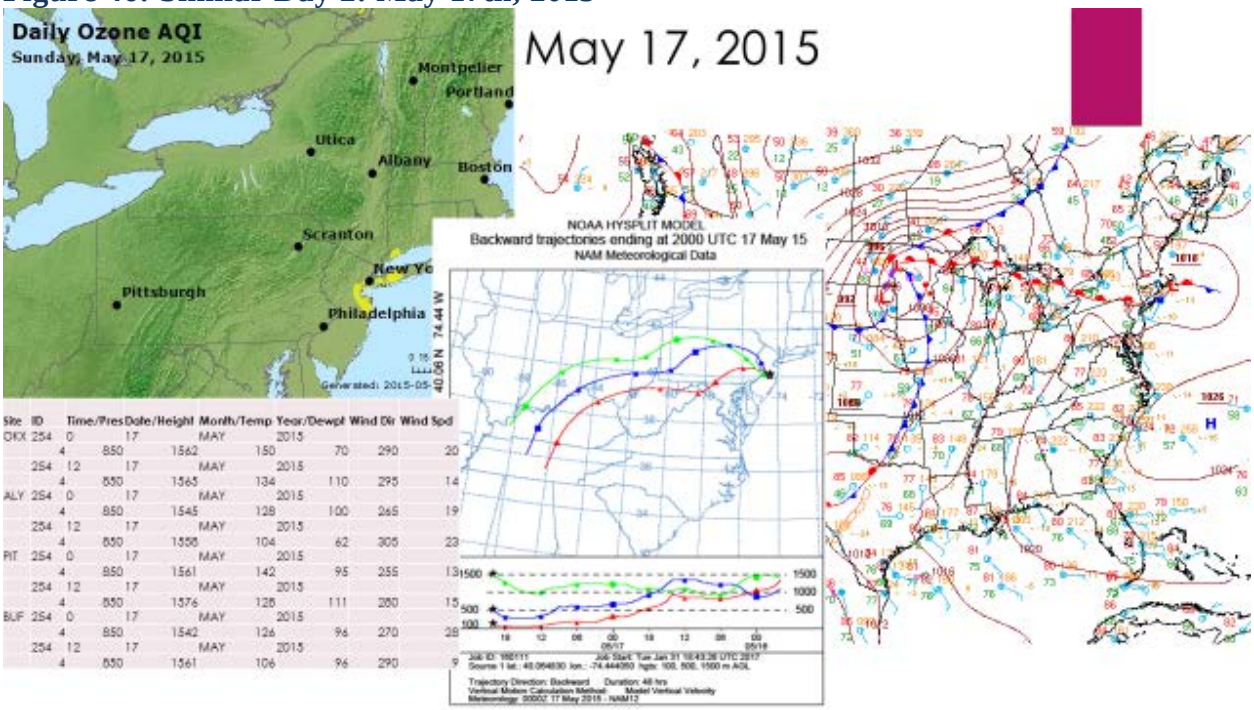
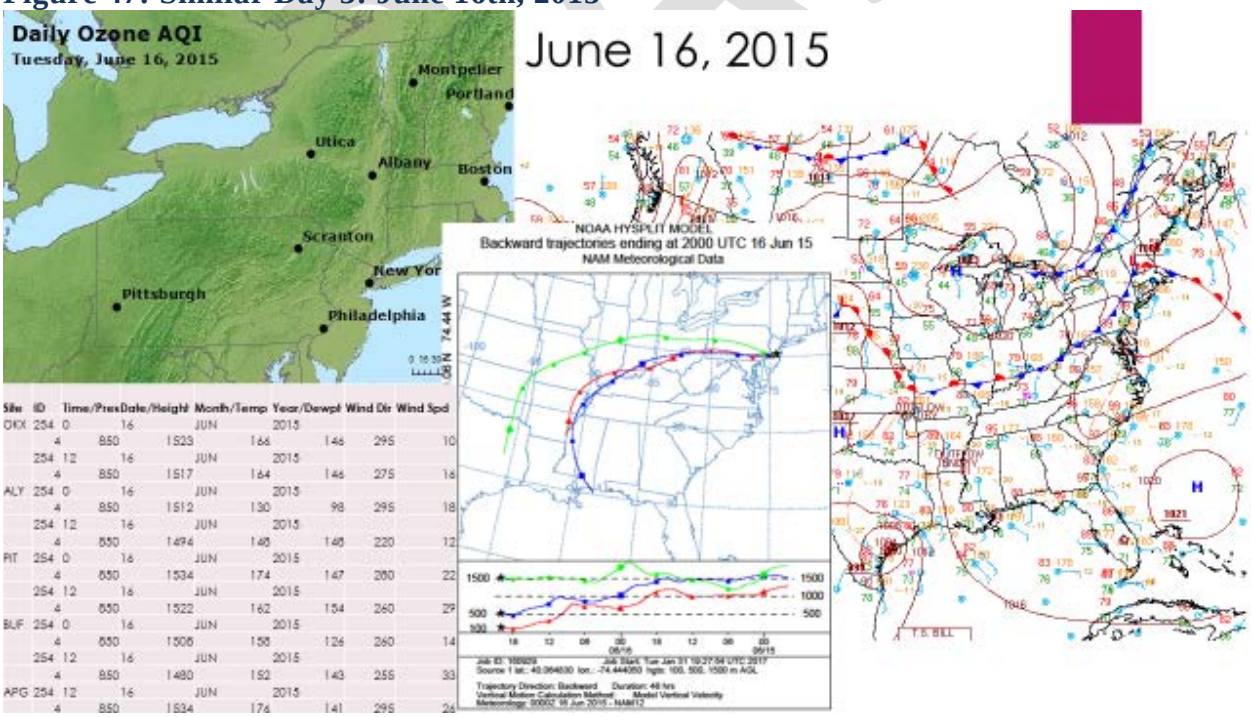


Figure 46: Similar Day 2: May 17th, 2015



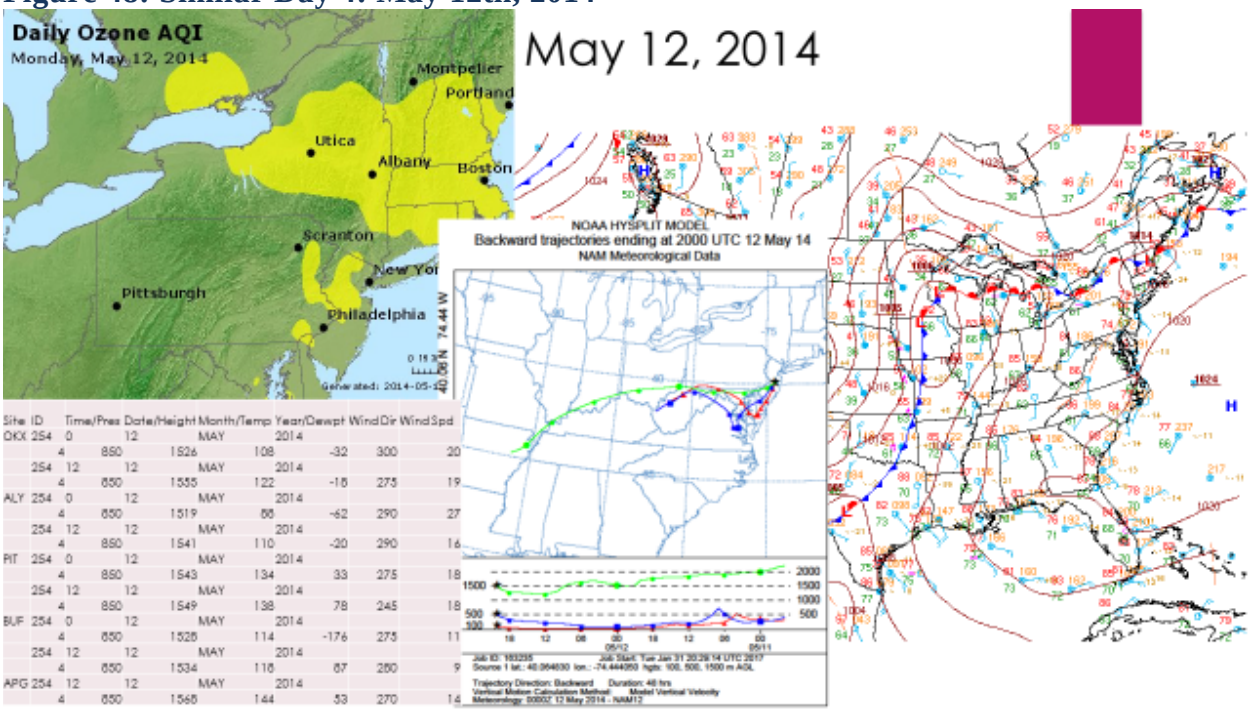
Site	ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
OKX	254	0	17	MAY	2015		
	4	850	1562	150	70	290	20
	254	12	17	MAY	2015		
	4	850	1565	134	110	295	14
ALY	254	0	17	MAY	2015		
	4	850	1545	128	100	265	19
	254	12	17	MAY	2015		
	4	850	1556	104	62	305	23
PIT	254	0	17	MAY	2015		
	4	850	1561	142	95	255	13
	254	12	17	MAY	2015		
	4	850	1576	128	111	260	15
BUF	254	0	17	MAY	2015		
	4	850	1542	126	96	270	28
	254	12	17	MAY	2015		
	4	850	1561	106	96	290	9

Figure 47: Similar Day 3: June 16th, 2015



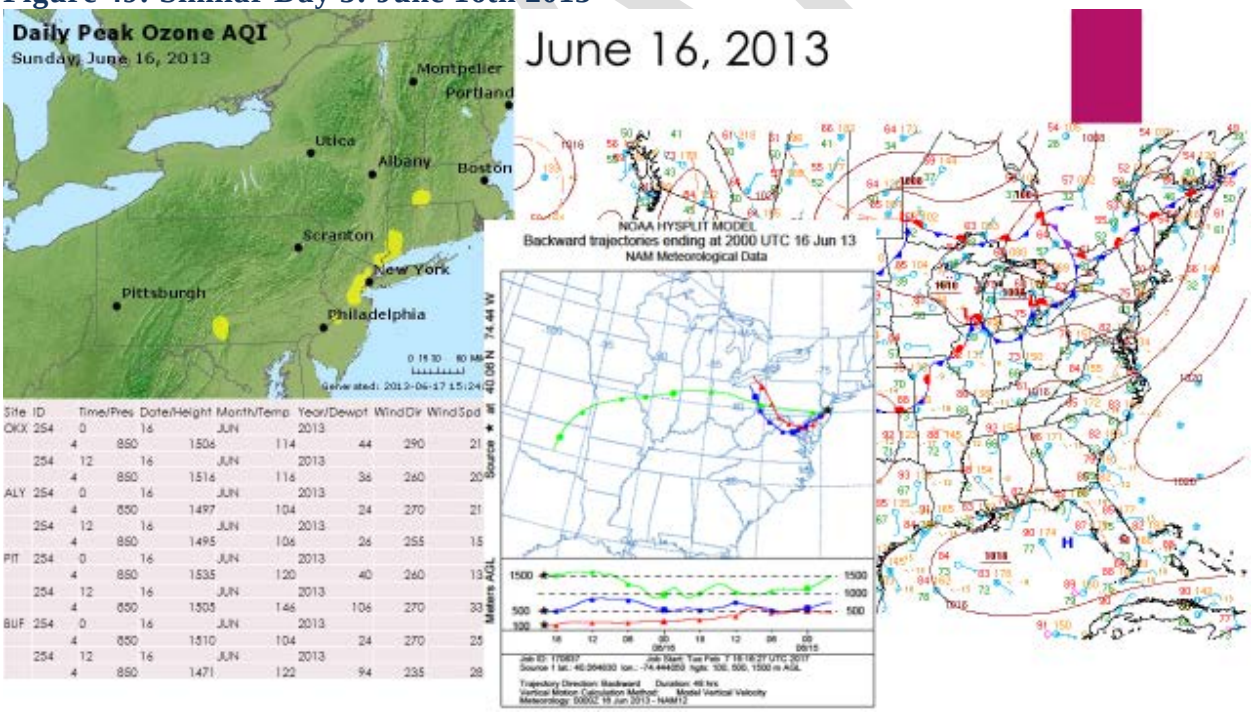
Site	ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	Wind Dir	Wind Spd
OKX	254	0	16	JUN	2015		
	4	850	1523	166	146	295	10
	254	12	16	JUN	2015		
	4	850	1517	164	146	275	16
ALY	254	0	16	JUN	2015		
	4	850	1512	130	98	295	18
	254	12	16	JUN	2015		
	4	850	1494	146	146	220	12
PIT	254	0	16	JUN	2015		
	4	850	1534	174	147	280	22
	254	12	16	JUN	2015		
	4	850	1522	162	154	260	29
BUF	254	0	16	JUN	2015		
	4	850	1506	156	126	260	14
	254	12	16	JUN	2015		
	4	850	1480	152	143	255	33
APG	254	12	16	JUN	2015		
	4	850	1534	174	141	295	26

Figure 48: Similar Day 4: May 12th, 2014



Site	ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	WindDir	WindSpd
OKX	254	0	12	MAY	2014		
		4 850	1526	108	-32	300	20
	254	12	12	MAY	2014		
		4 850	1555	122	-16	275	19
ALY	254	0	12	MAY	2014		
		4 850	1519	86	-62	290	27
	254	12	12	MAY	2014		
		4 850	1541	110	-20	290	16
PIT	254	0	12	MAY	2014		
		4 850	1543	134	33	275	18
	254	12	12	MAY	2014		
		4 850	1549	138	78	245	18
BUF	254	0	12	MAY	2014		
		4 850	1528	114	-176	275	11
	254	12	12	MAY	2014		
		4 850	1534	116	67	250	9
APG	254	12	12	MAY	2014		
		4 850	1565	144	53	270	14

Figure 49: Similar Day 5: June 16th 2013



Site	ID	Time/Pres	Date/Height	Month/Temp	Year/Dewpt	WindDir	WindSpd
OKX	254	0	16	JUN	2013		
		4 850	1506	114	44	290	21
	254	12	16	JUN	2013		
		4 850	1516	116	36	260	20
ALY	254	0	16	JUN	2013		
		4 850	1497	104	24	270	21
	254	12	16	JUN	2013		
		4 850	1495	106	26	255	15
PIT	254	0	16	JUN	2013		
		4 850	1535	120	40	260	13
	254	12	16	JUN	2013		
		4 850	1505	146	106	270	33
BUF	254	0	16	JUN	2013		
		4 850	1510	104	24	270	25
	254	12	16	JUN	2013		
		4 850	1471	122	94	235	28

Figure 50: Similar Day 6: June 17th, 2013

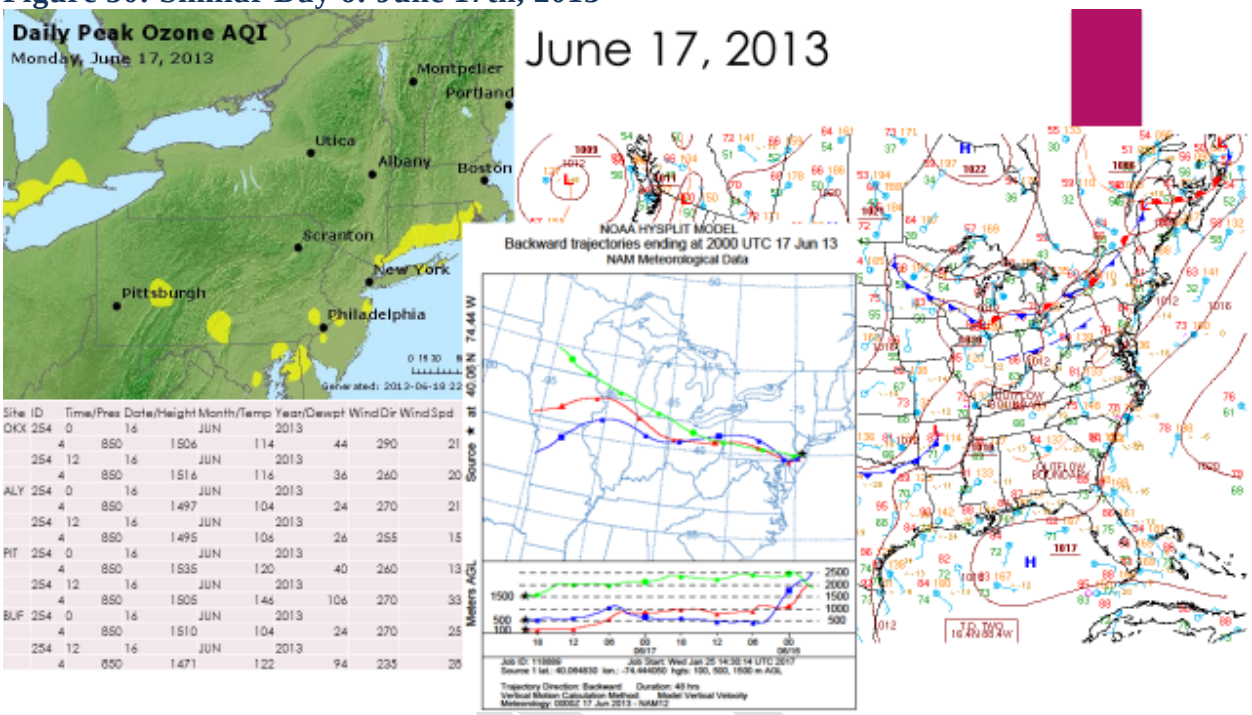
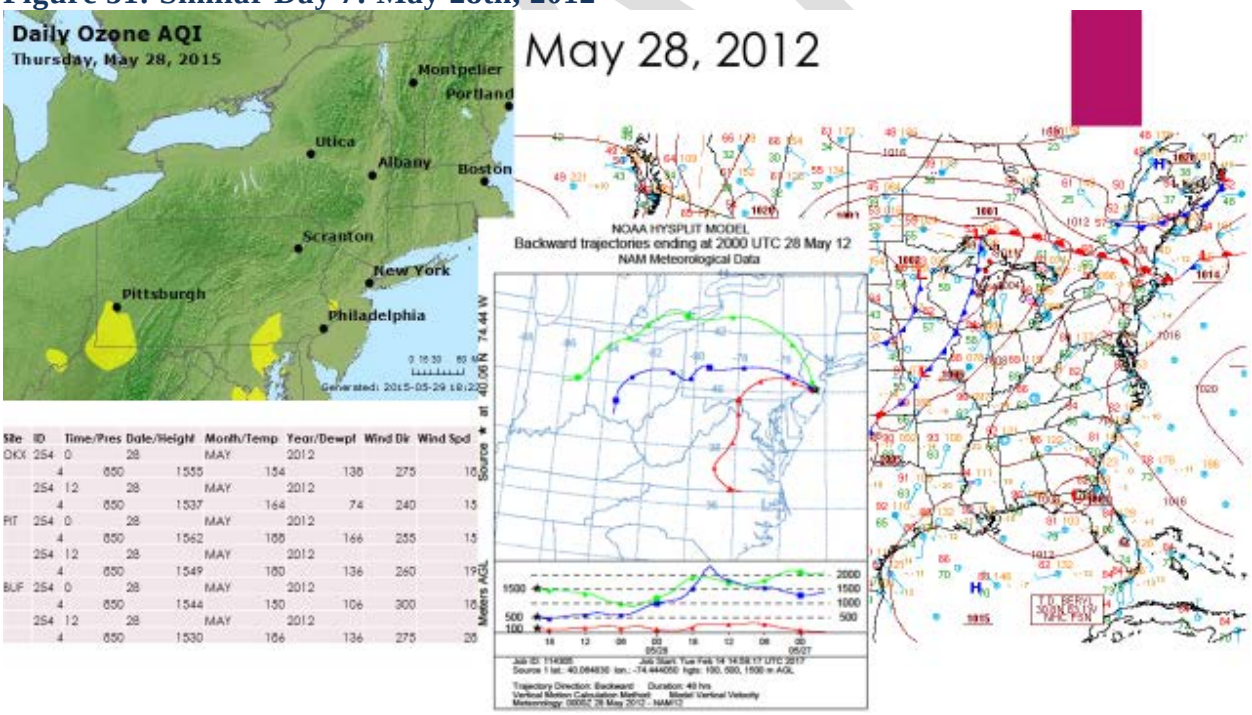


Figure 51: Similar Day 7: May 28th, 2012



The similar day analysis and figure comparison demonstrates that on days when winds came from the northwest and west ozone levels are ordinarily low. It also shows that on days when high pressure systems migrate from the northwest, New Jersey typically experiences lower ozone values.

2. Evidence that the event, monitors, and exceedance meet the key factors for tier 2 clear causal analysis

Emissions from the burning of forests and vegetation have been shown to add several pollutants that enhance ozone formation including fine particle matter, non-methane hydrocarbons, black carbon, and carbon monoxide. Estimates of the emissions that caused these high levels in the ambient air were estimated in the millions of tons. Specifically, this single fire has contributed an estimated 85 million tons of carbon-dioxide-equivalent emissions. The large amount of acreage burned equaled over 5,900 square kilometers (589,995 hectares) that resulted in millions of tons of emissions of ozone precursor emissions.

i. Emissions over distance (Q/d) analysis

EPA guidance[20] recommends conducting a Q/d analysis as a rough assessment of the ability of a wildfire to cause increased ozone concentrations. The Q/d analysis is a simple comparison of the ratio of the emissions (Q), the daily tons of VOC and NOx emitted from the fire, to distance (d) in kilometers from the fire to the point of concern. EPA guidance indicates that a fire should have a Q/d in excess of 100 tons per day per kilometer of distance (tpd/km) in order to be considered to have a clear causal impact on ozone. EPA developed this value based on analyses of four fires which occurred in 2011.

Estimate of emissions (Q)

The emissions from the fire can be estimated using information from EPA's AP-42, Compilation of Air Emission Factors, Section 13.1, Wildfires and Prescribed Burning. Emission factors are presented for various pollutants by fire and fuel configurations for the fire. The Alberta government reported that by June 10, 2016 the fire ultimately covered 589,995 hectares (1,457,909 acres) with a perimeter of 996 kilometers (618 miles). This is an extremely immense area that was consumed by the fire. The table below, taken from Table 13.1-2 of AP-42, Wildfires and Prescribed Burning, provides the emission factors used to estimate emissions.

Table 8: Emission Factors from Table 13.1-2 of AP-42, 10/96

		Emission Factors (kg/Hectare		
Geographic Area	**Area Consumed by Wildfire (hectares)**	**Particulate**	**Volatile Organics (Expressed as Methane)**	**Nitrogen Oxides**
Pacific Northwest (Region 6)	589,995	1,144	1,620	269

[20] Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations, Final, EPA, September 2016

New Jersey's Q/d analysis did not include the smoldering of previously burned areas which use higher emission factors for some compounds or the additional fuels burned over the southern Canada or Mexico fires (Figure 106). In order to estimate the daily emission rate and to obtain a worst case estimate, it is assumed that the entire amount of area burned occurred on one day. The actual period of time that the fire burned or smoldered was many weeks.

Volatile Organics: 589,995 hectares * 1,620 kg/Hectare * 1 Mg/1000 kg = **955,792 Mg**

EPA recommends, in the exceptional events guidance, that only 60% of the hydrocarbons from wildfires should be considered reactive. Therefore, the reactive hydrocarbon (HC) emissions become:

955,792 * 0.6 = 573,475 MG = **573,475 metric tons/day** of reactive HC emitted daily during the period of interest.

Nitrogen Oxides: 589,995 hectares * 269 kg/Hectare * 1 Mg/1000 kg = **158,709 Mg/day = 158,709 metric tons/day**

No adjustments are suggested for the NOx emissions to account for reactivity.

Total Amount of Ozone Forming Compounds (volatile organics plus nitrogen oxides) from the fire under a worst-case scenario: **732,184 tons/day**

To get a more realistic estimate of the emissions, it is assumed that the fire only lasted for a period of 30 days. While this is also an over-estimate of actual emissions, it is more realistic than the worst case assumption.

Volatile Organics: 589,995 hectares * 1,620 kg/Hectare * 1 Mg/1000 kg = **955,792 Mg**

EPA recommends, in the exceptional events guidance, that only 60% of the hydrocarbons from wildfires should be considered reactive. Therefore, the reactive hydrocarbon emissions for the 30 day period become:

955,792 * 0.6 = 573,475 MG * 1/30 days = 19,116 MG/day = **19,116 metric tons/day** of reactive HC emitted daily during the period of interest

Nitrogen Oxides: 589,995 hectares * 269 kg/Hectare * 1 Mg/1000 kg * 1/30 day = **5290.3 Mg/day = 5,290 metric tons/day**

No adjustments are suggested for the NOx emissions to account for reactivity.

Total Amount of Ozone Forming Compounds from the fire under a more realistic assumption: **24,406 metric tons/day**

Estimate of distance from the fire (d)

New Jersey estimated the distance from the Fort McMurray fire to the Rider University monitor located in Trenton, New Jersey since this monitor is centrally located within the state and experienced ozone violations during the exceptional event. Google maps (www.mapdevelopers.com/distance_from_to.php) was used to determine the straight line distance between Fort McMurray and Trenton, New Jersey of 1,995 miles (3,210 kilometers).

Q/d Estimate

Using the values determined above, Q/d becomes 732,184 tons/day divided by 3,210 km or 228 tpd/km under worst case assumptions. Using conservative, but still over-estimated, assumptions, the Q/d would be 24,406 tpd divided by 3,210 km or 7.6 tpd/km. This 7.6 tpd/km conservative value is well below the EPA recommended level of 100 tpd/km above which would indicating a clear causality. Noting the wide variability in emissions estimates from different approaches, and as the Q/d method does not generally satisfy the expectation of a clear causal impact, we presented other evidence demonstrating that the plume from the Fort McMurray fire caused elevated ozone levels in New Jersey.

ii. Event-related emissions versus non-event **emissions** (e.g.; NOx from CSAPR sources on exceptional event days compared to a typical ozone season day with exceedances)

The second largest cluster of ozone exceedances in New Jersey during 2016 occurred on July 21 and 22. The July wind trajectories also originated from Pennsylvania, Delaware, Maryland, Michigan, Virginia, New York and New Jersey, with some contribution from Illinois and Indiana. Similarly during the days of the exceptional event, forty-eight hour back trajectories from Colliers Mills show air originating from Pennsylvania, Delaware, Maryland, Michigan, Virginia, West Virginia, western New York, Ontario, and New Jersey. Maximum temperatures at Trenton were comparable during the two events with a temperature range of 87° F to 90° F in May and a range of 88° F to 93° F in July. Synoptic weather patterns were generally similar for the two events.

New Jersey reviewed the activities of electric generating units (EGUs) from six states (MD, VA, WV, PA, NJ, MI) as an indicator of upwind EGU emissions during a regional heat wave. The PJM Mid-Atlantic maximum hourly loads peaked at 44,462 Megawatt-hours (MWh) in May, while the July loads peaked at 53,351 MWh, a 20% increase. Correspondingly, average daily EGU NOx emissions in the PJM Mid-Atlantic went from 576 tons in May to 776 tons in July, a 35% increase and maximum hourly NOx emissions went from 31 to 43 tons, a 39% increase. The first three weeks of May had seen below normal temperatures and only began to switch to above normal on May 23, 2016. Residual heating refers to the heat content of buildings and the energy needed to cool them. Because the average temperature had been in the 50 degree Fahrenheit range for several weeks in May, there is less overall heat to remove in buildings by air conditioning than if the buildings are “heat soaked” after several days of temperatures being in the high 70’s to low 80 degree Fahrenheit range. The lack of residual heating in May, as

opposed to mid-July, accounts for the reduced air conditioning and, therefore, lower electric loads, generation, and NOx emissions.

During the two days of May 25 and 26, 2016, respectively, there were 16 and 10 site exceedances of the 70 ppb NAAQS with maximum daily ozone values of 90 and 88 ppb. The two day July hot spell produced 3 and 7 site exceedances, with peak ozone values of 74 and 81 ppb. The daily NOx tonnage from electric generating units during the May event was 26% lower than that in July, (576 vs 776 tons per day). This seeming inverse association is the opposite of what has been previously observed between High Electric Demand Day (HEDD) EGU emission profiles and ozone exceedances. Therefore, large stationary sources were not emitting NOx at levels typically seen when high ozone episodes occur at New Jersey monitors during ozone season at the time the May exceedance. The extent of ozone exceedances seen in New Jersey typically associated with peak EGU operations was also much less than what was seen during May 25-26, 2016 due to the Fort McMurray wildfire.

iii. Evidence that the fire emissions affected the monitors

The presence of smoke from wildfires can be determined in the outside air by looking for elevated levels of certain pollutants, called markers, that are key components of wood smoke but are not usually found in outside air except in trace amounts. Primary markers for wood smoke emissions include potassium (K) and levoglucosan.[21] High levels of potassium in the outdoor air usually means that wood smoke is present and causing an increase in the outdoor air concentrations of other pollutants from wood smoke emissions as well. Potassium is one of the parameters for which fine particle samples are analyzed through EPA's PM2.5 Speciation Trends Network from sampling locations nationwide. The samplers operate on a three-day sampling schedule, and, unfortunately, samples for analysis of the potassium levels in New Jersey's outdoor air were not collected during the May 25 and 26, 2016 exceptional event. Preliminary data on potassium levels from the PM2.5 Speciation sites in Michigan were obtained with permission from the State of Michigan for May 2016. Both potassium and ozone levels were elevated on May 24, 2016 (compared to the levels measured on the days before and after the wildfire) and it has been shown that air traveled over Michigan on May 24, 2016 and continued into New Jersey on May 25 and 26, 2016 to impact the air levels of ozone in New Jersey.

As shown in Table 9 and Figure 52, the highest levels of potassium in Michigan's air were found on May 24, 2016 at the four sites measured in the state. The May 25 and 26, 2016 back trajectories from New Jersey, determined using the HYSPLIT Model as shown in Figures 104 and 105, show that this high potassium and wood smoke laden air mass would have been transported to New Jersey within the next 24 to 48 hours and affected New Jersey's ozone levels.

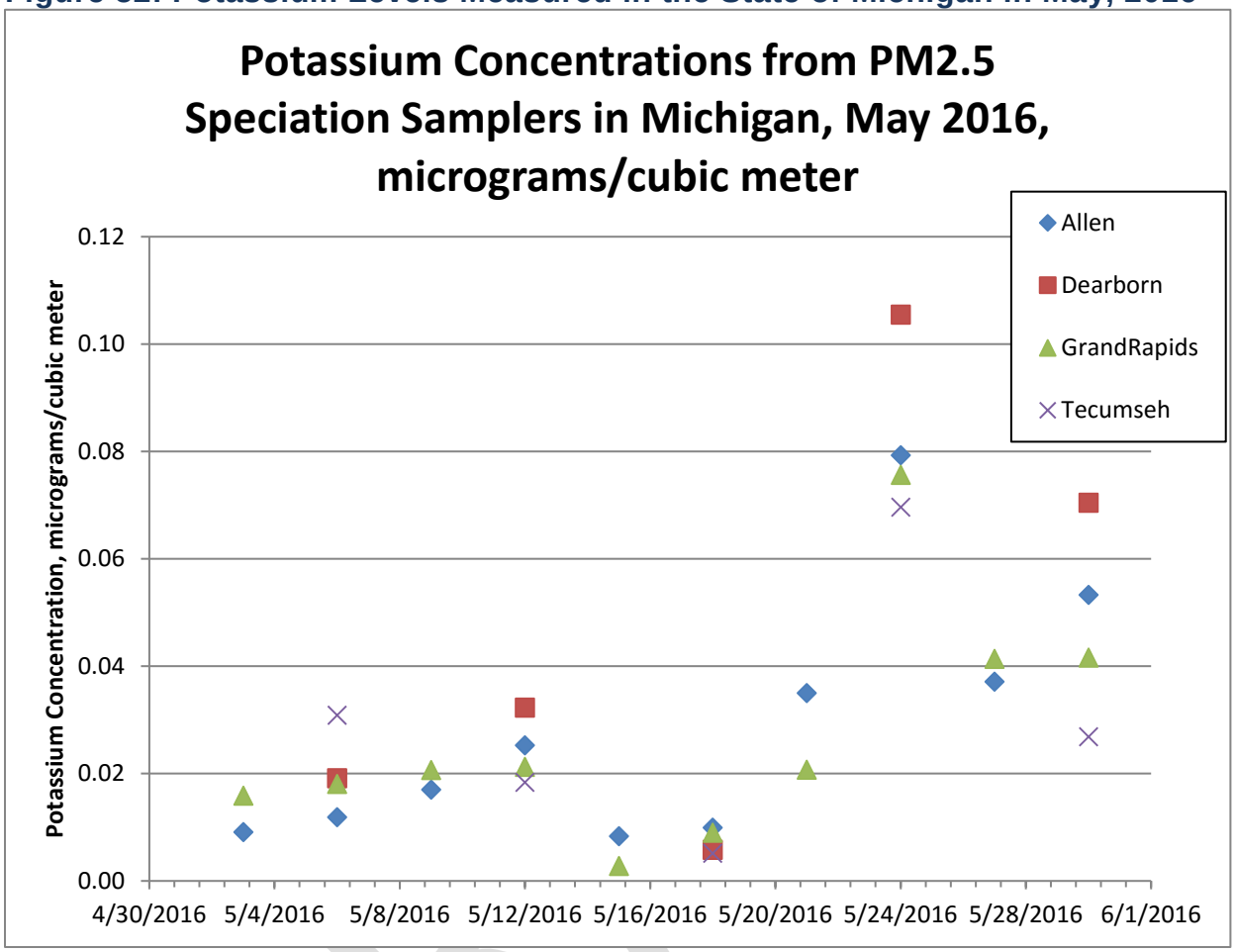
[21] "A comparison of four receptor models used to quantify the boreal wildfire smoke contribution to surface PM2.5 in Halifax, Nova Scotia during the BORTAS-B experiment", Gibson, Haelssig, et al, Atmos. Chem. Phys., 15, 815-827, 2015

Table 9: Preliminary Potassium (K) Concentrations Measured from PM2.5 Speciation Sites in Michigan, May, 2016, micrograms/cubic meter

Date	Allen	Dearborn	GrandRapids	Tecumseh
5/3/2016	0.0091		0.0159	
5/6/2016	0.0119	0.0191	0.0181	0.0309
5/9/2016	0.0170		0.0206	
5/12/2016	0.0253	0.0323	0.0212	0.0184
5/15/2016	0.0084		0.0028	
5/18/2016	0.0099	0.0058	0.0090	0.0052
5/21/2016	0.0350		0.0207	
5/24/2016	0.0793	0.1055	0.0756	0.0696
5/27/2016	0.0371		0.0414	
5/30/2016	0.0533	0.0705	0.0416	0.0269

K=potassium concentrations, micrograms/cubic meter

Figure 52: Potassium Levels Measured in the State of Michigan in May, 2016



iv. Evidence of changes in the spatial/temporal patterns of ozone and/or NOx at NY/OH/PA monitors in comparison to smoke plume

The smoke plume from the Canadian fires and those that occurred in Mexico merged in the central U.S. (see the section on weather patterns during the time of the event) and caused poor air quality in several states as the emissions moved across the country. High ozone and particulate levels were first noticed in the upper central U.S. on May 21, 2016 and increasing levels of ozone and particulate matter were present for the next two days. From May 25 to 26, 2016, higher ozone and PM2.5 levels began to appear in the eastern U.S. as the emissions from Fort McMurray were carried into the eastern states.

Airnow maps of the AQI on the days before and during the exceptional event are shown in Figures 53 to 62. Unhealthful air quality occurred on May 25 and 26, 2016 in New Jersey due to the transported emissions of wood smoke.

Figure 53: AQI on May 21, 2016

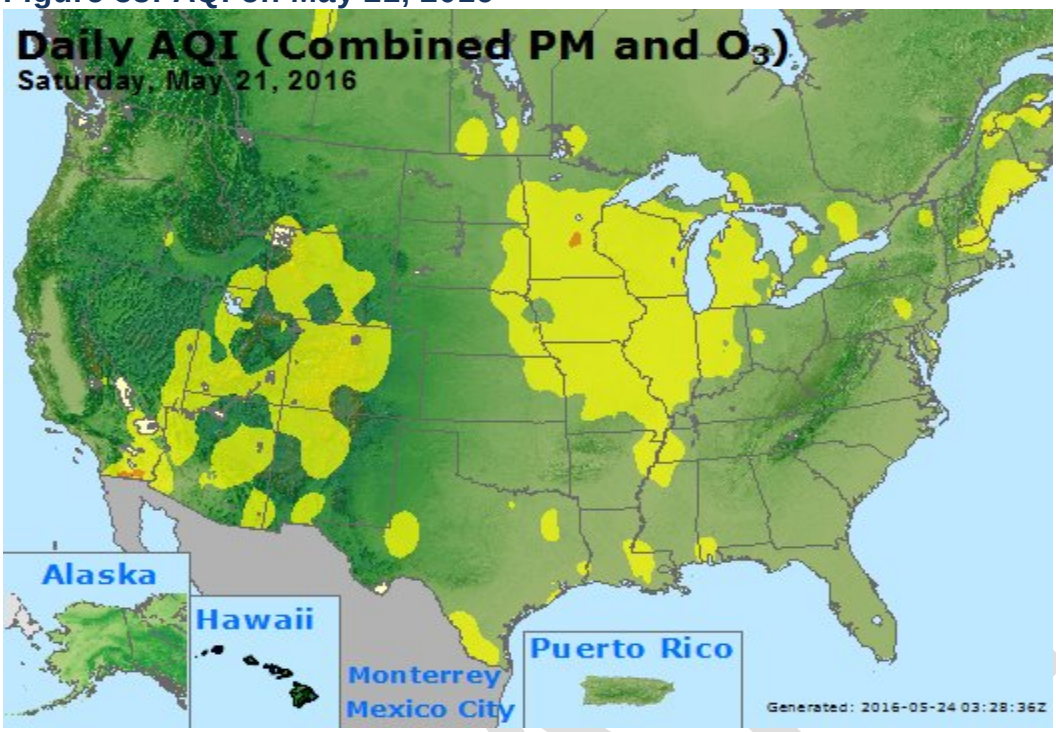


Figure 54: AQI on May 22, 2016

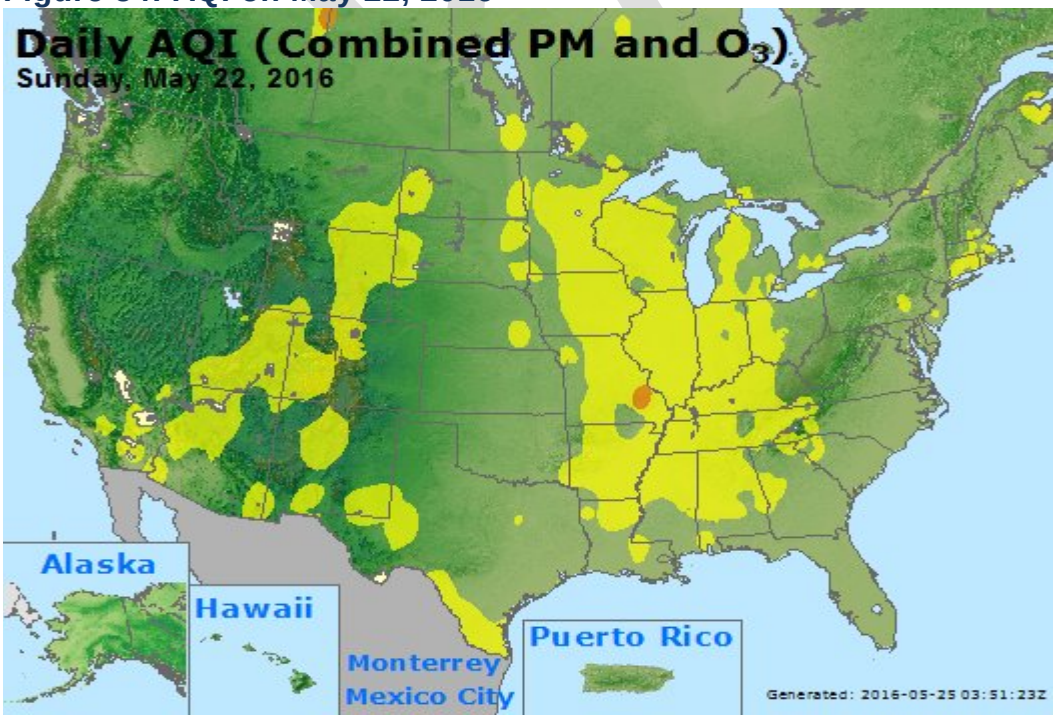


Figure 55: AQI on May 23, 2016

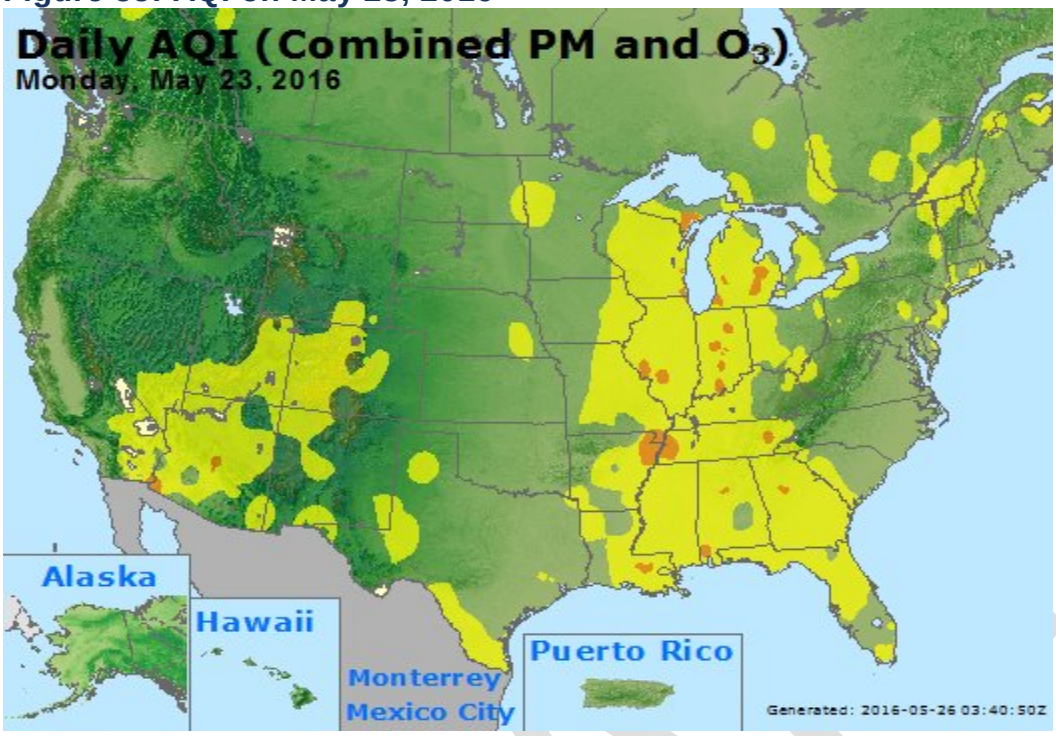


Figure 56: AQI on May 24, 2016

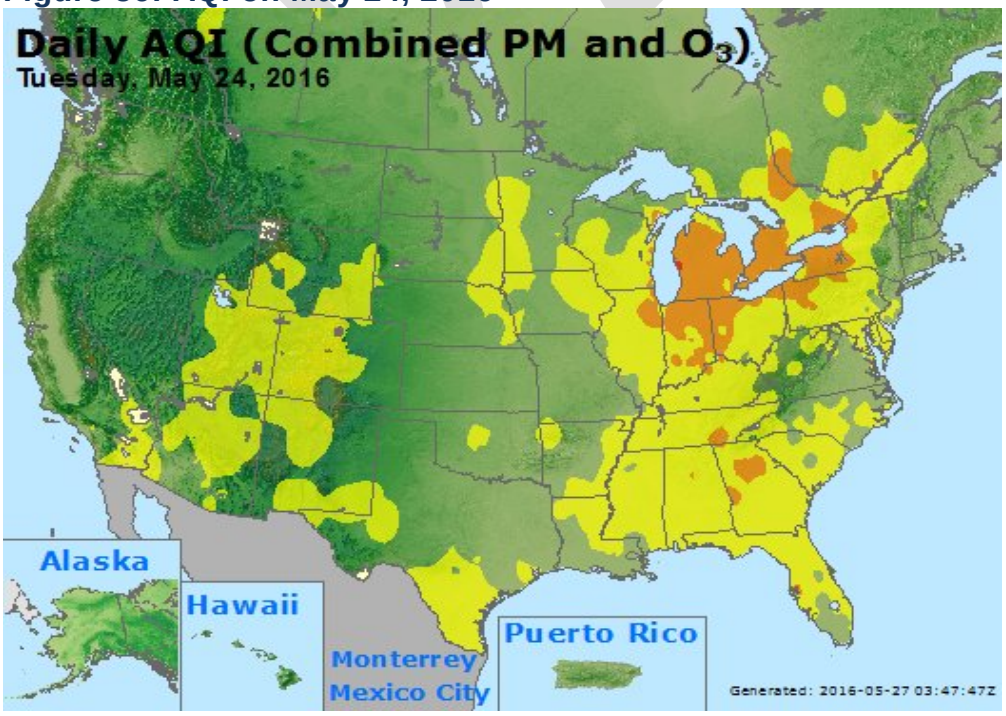


Figure 57: AQI on May 25, 2016

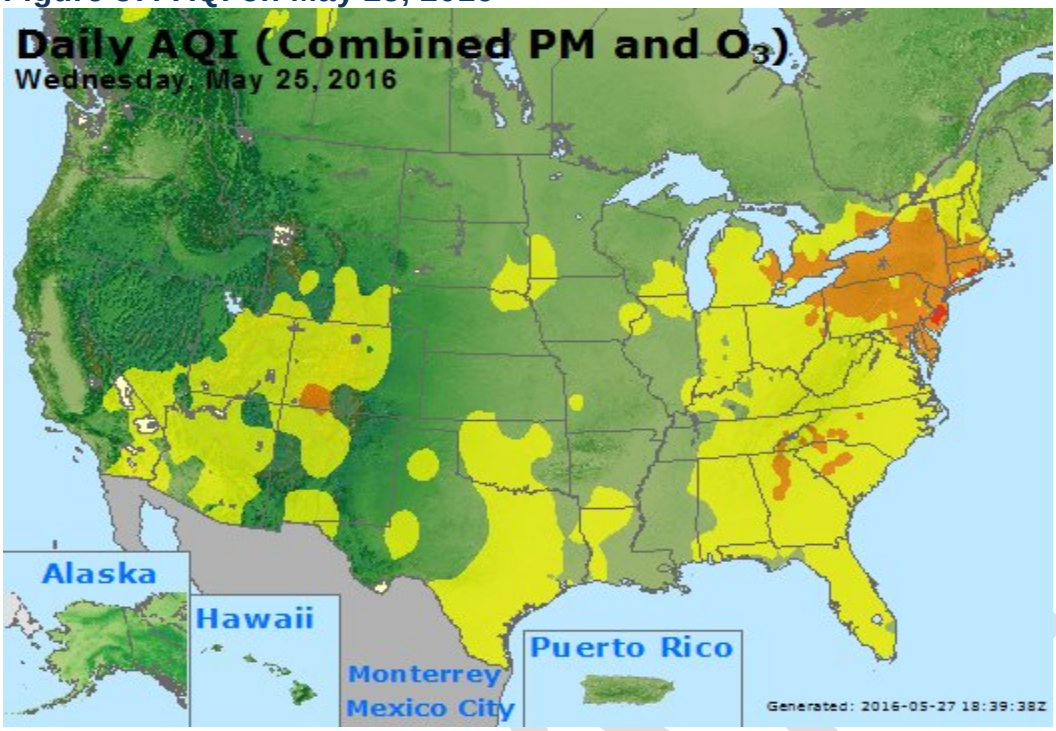


Figure 58: AQI on May 26, 2016

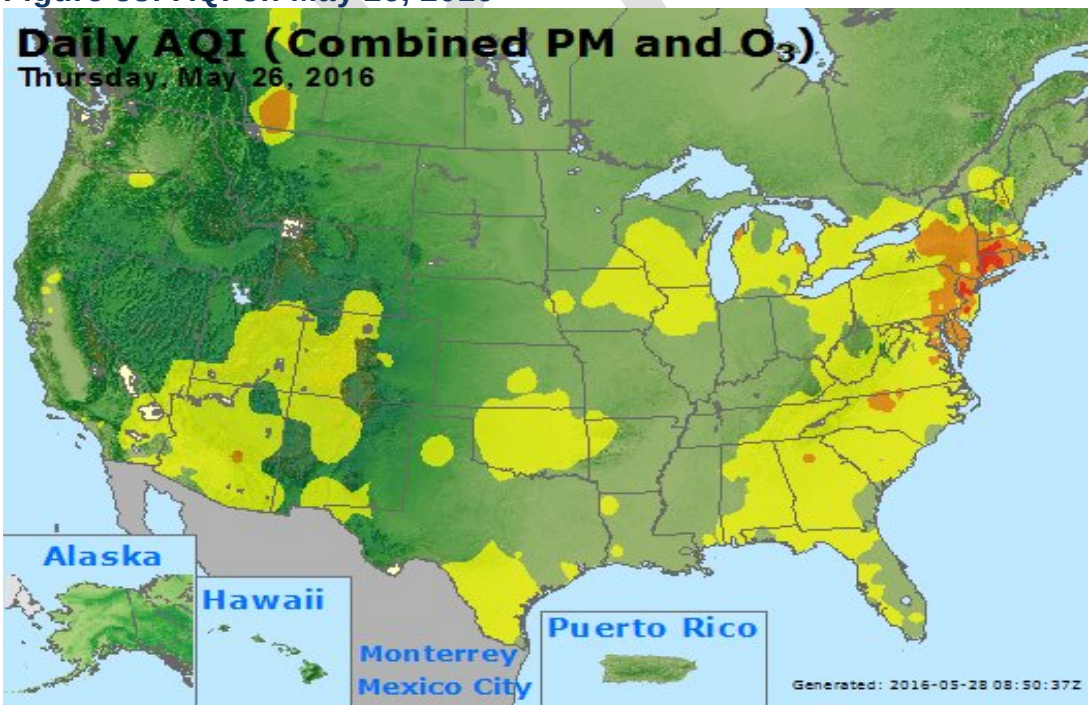


Figure 59: AQI on May 27, 2016

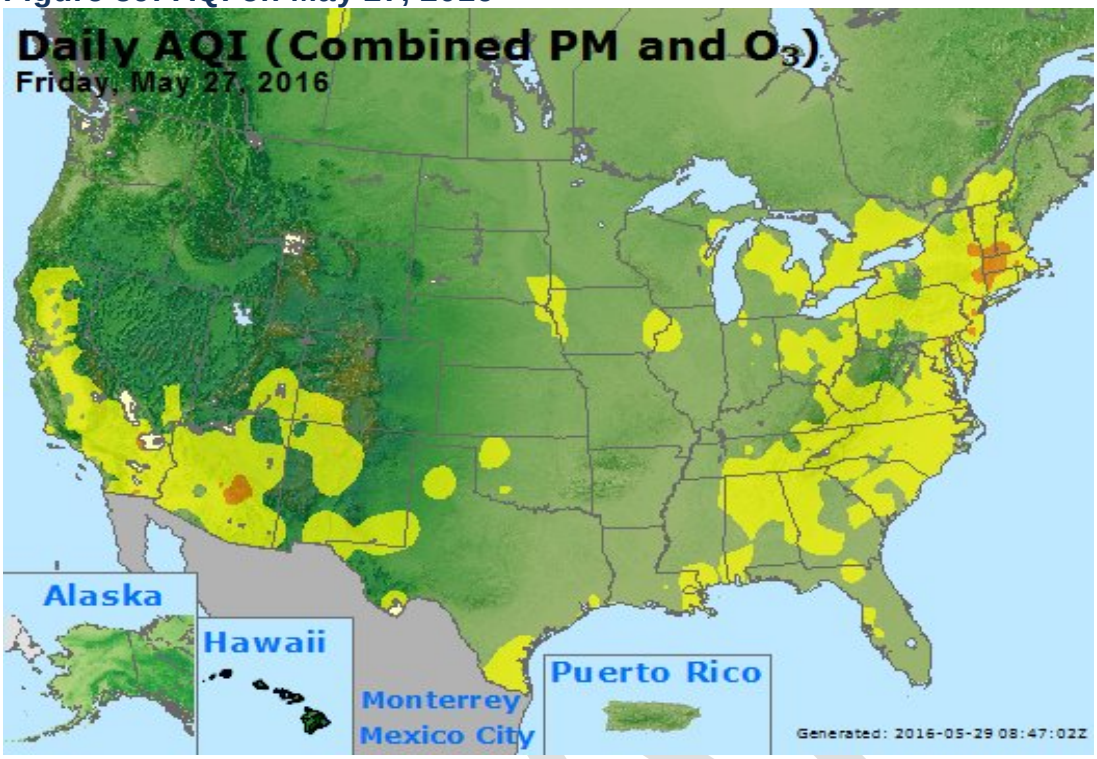


Figure 60: AQI on May 28, 2016

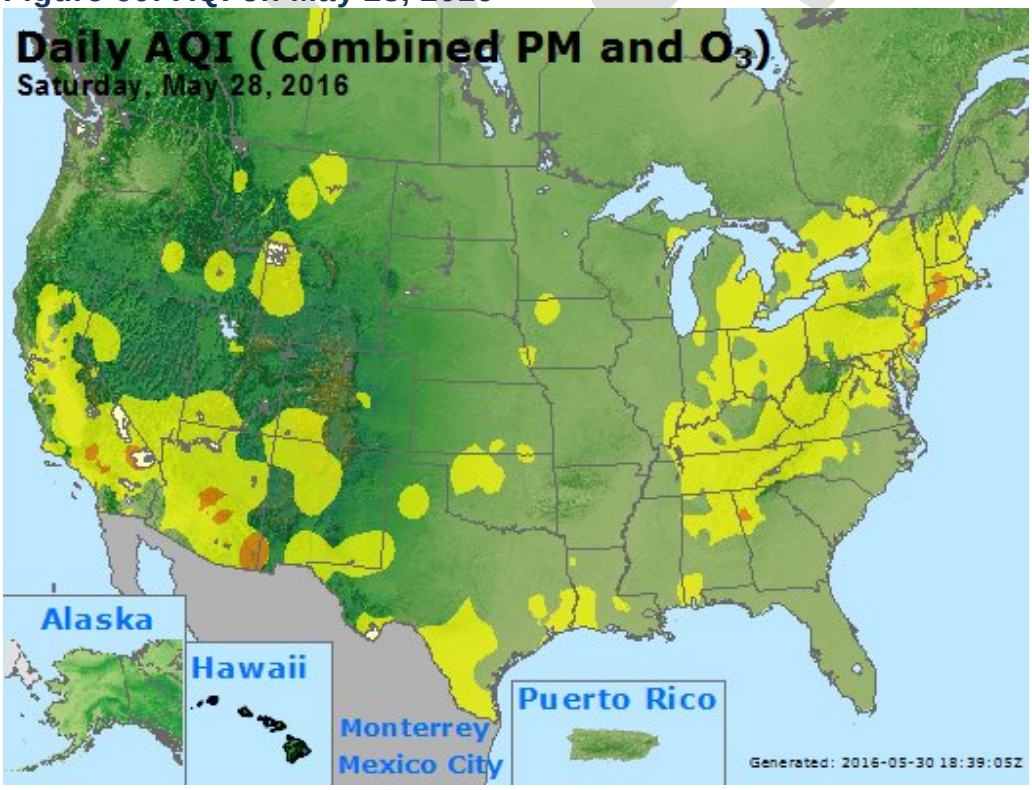


Figure 61: AQI on May 29, 2016

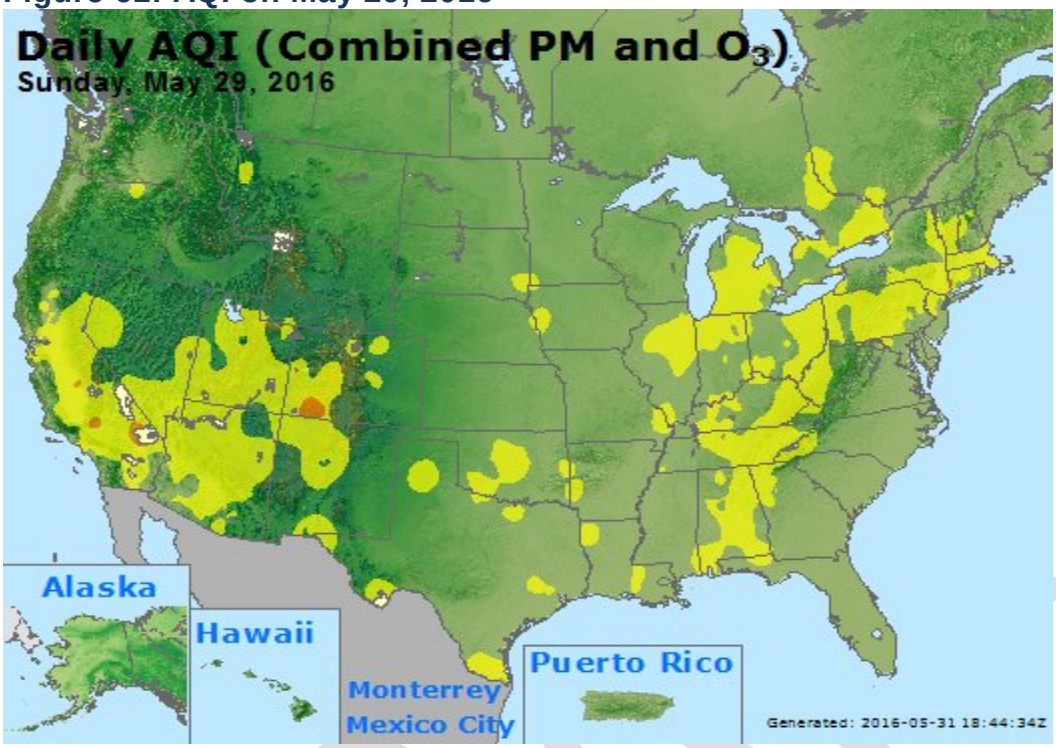
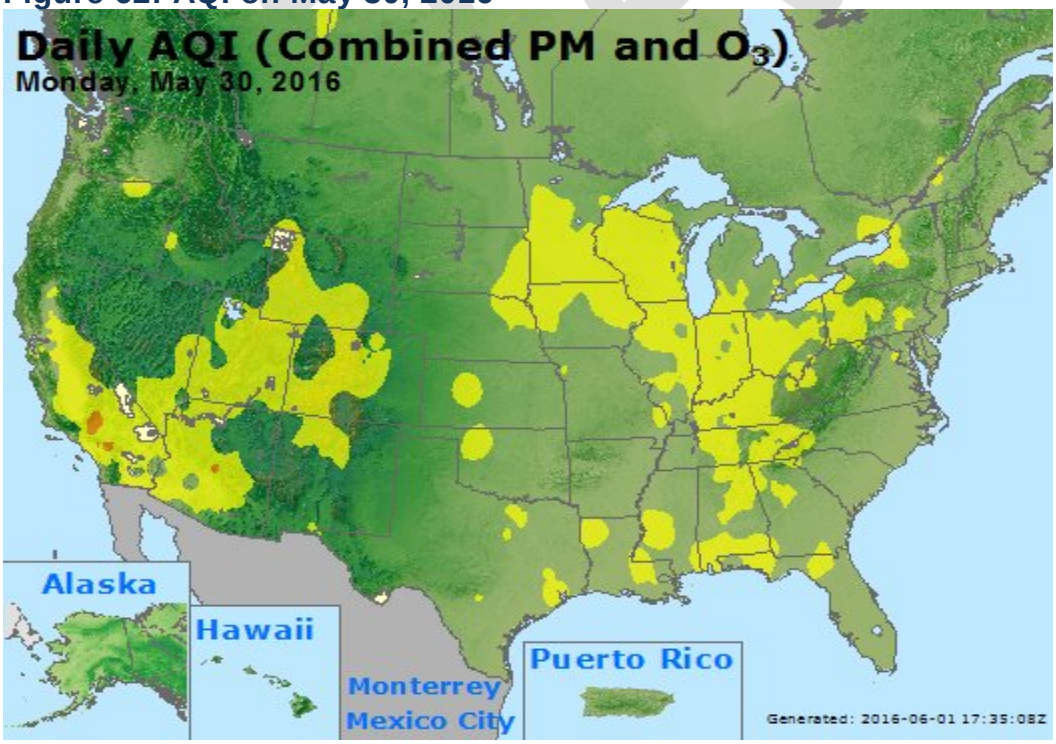


Figure 62: AQI on May 30, 2016



v. Visual photographic evidence that the plume impacted the ground (Hazecam pictures from Newark and Brigantine)

New Jersey operates, with the assistance of NESCAUM, remote cameras at two locations in the State to assess visibility conditions throughout the year. These cameras are located at Newark, NJ in the northern part of the state, and Brigantine, NJ in the southern part of the state. Shown below in Figures 63 to 66 are pictures taken during and after the exception event occurred in New Jersey. Note that on the day of the event, May 25, 2016, the skylines of New York and Atlantic City are obscured, discolored and hazy in appearance. On the days after the exceptional event, when the smoke plume moved out of the southern and northern parts of the state, a noticeable improvement in visibility and haze conditions occurred.

Figure 63: Hazecam Picture from Newark, NJ on May 25, 2016, 3:00 PM

Figure 64: Hazecam Picture from Newark, NJ on May 29, 2016, 5:00 PM

Figure 65: Hazecam Picture from Brigantine, NJ on May 25, 2016, 6:00 PM

Figure 66: Hazecam Picture from Brigantine, NJ on May 28, 2016, 5:00 PM

vi. Concentrations of supporting ground-level measurements

Discussion of 2016 data

On Wednesday, May 25, 2016, sixteen out of seventeen monitors in New Jersey recorded exceedances of the 70 ppb 8-hour average ozone NAAQS of 2015. The only station in New Jersey that did not exceed the new 70 ppb ozone NAAQS was Bayonne with a concentration of 69 ppb. All sixteen stations also exceeded the 75 ppb 8-hour ozone NAAQS of 2008, and two stations exceeded the 84 ppb 8-hour ozone NAAQS of 1997. The highest 1-hour average ozone concentration recorded was 90 ppb at Colliers Mills. The data from the Washington Crossing station, which is maintained by EPA as part of the Clean Air Status and Trends Network (CASTNET), is included in this analysis.

On Thursday, May 26, 2016, ten exceedances were recorded in New Jersey of the 70 ppb 8-hour average ozone NAAQS of 2015. Nine stations also exceeded the 75 ppb 8-hour ozone NAAQS of 2008, and five stations exceeded the 84 ppb 8-hour ozone NAAQS of 1997. The highest 1-hour average ozone concentration recorded on May 26, 2016 was 88 ppb at the Flemington station. Table 10 summarizes the daily maximum 8-hour average ozone concentrations recorded in New Jersey from May 21, 2016 through May 29, 2016 with the exceedances highlighted.

Table 10: Ozone Concentrations (ppb) in NJ on May 21 to May 29, 2016

Site Name	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29
Ancora State Hospital	39	42	49	47	76	64	61	54	33
Bayonne	38	47	51	36	69	76	54	68	47
Brigantine	53	49	53	49	79	62	52	45	21
Camden Spruce St	41	45	54	48	78	68	59	61	40
Chester	43	48	46	46	83	86	64	56	61
Clarksboro	37	44	56	55	83	70	59	58	36
Colliers Mills	43	52	59	57	90	70	66	62	40
Columbia	39	37	40	46	76	73	63	50	57
Flemington	41	46	49	53	83	88	69	69	61
Leonia	44	49	52	40	86	85	62	77	58
Millville	44	42	49	53	81	69	58	52	29
Monmouth University	46	51	53	45	81	65	49	50	37
Newark Firehouse	36	45	38	38	81	77	49	65	50
Ramapo	45	47	46	48	79	81	71	55	57
Rider University	41	41	48	54	82	82	67	70	55
Rutgers University	42	47	55	46	84	86	75	73	53
Washington Crossing*	33	44	51	55	83	86	74	74	57

*operated by EPA

exceeds 70 ppb NAAQS of 2015
exceeds 75 ppb NAAQS of 2008
exceeds 84 ppb NAAQS of 1997

The severity and widespread nature of this 2-day period was unusual and was not repeated in the rest of 2016. Sixteen (16) out of seventeen (17) monitors recorded their highest daily maximum 8-hour average ozone concentrations for 2016 during this 2-day period. The next most severe ozone event occurred on July 22, 2016 where only seven monitors exceeded the NAAQS, and none exceeded 84 ppb, the ozone NAAQS of 1997. Table 11 compares the concentrations measured during this period with the 4 highest concentrations for the year. The shaded boxes show that the 1st maximum level for the year occurred on either May 25 or 26, 2016.

Table 11: O_3 Daily Max Values Compared with 4 Highest Daily Max in NJ for 2016

	Daily Max 8-Hr O_3 (ppb)		2016 Daily Maximum 8-Hr O_3 Concentrations (ppb)			
	5/25/2016	5/26/2016	Max	2nd Max	3rd Max	4th Max
Ancora State Hospital	76	64	76	76	69	69
Bayonne	69	76	76	74	69	69
Brigantine	79	62	79	68	67	63
Camden Spruce St	78	68	81	78	78	78
Chester	83	86	86	83	72	69
Clarksboro	83	70	83	79	77	76
Colliers Mills	90	70	90	77	73	72
Columbia WMA	76	73	76	73	72	66
Flemington	83	88	88	83	78	78
Leonia	86	85	86	85	77	75
Millville	81	69	81	70	69	69
Monmouth Univ	81	65	81	73	72	70
Newark Firehouse	81	77	81	77	71	70
Ramapo	79	81	81	79	79	72
Rider Univ	82	82	82	82	76	74
Rutgers Univ	84	86	86	84	78	76
Washington Crossing*	83	86	86	83	75	74

* Site operated by EPA

Discussion of 5-years of ozone data from 2012-2016

The distinctive nature of the 2016 data is also evident when comparing them to the last five years, 2012-2016. For fourteen of the seventeen monitors, the daily maximum concentrations recorded on May 25 or May 26, 2016 were equal to or greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. For the remaining three monitors, their daily maximum concentrations recorded on May 25 or May 26, 2016 were equal or greater than the 98th percentile concentration for the 5-year period. The daily maximum concentrations recorded on May 25 and May 26, 2016 at Colliers Mills, Flemington, Leonia, and Washington Crossing were the highest concentrations recorded by these stations during this 5-year period.

Table 12 summarizes the daily maximum 8-hour ozone concentrations measured by New Jersey monitors from May 25-28, 2016 along with each monitor's respective 99th to 97th percentile daily maximum 8-hour ozone concentrations for the 5-year period 2012-2016.

Table 12: Daily Maximum 8-Hr O_3 Concentrations Measured in NJ for May 25-26, 2016

	Daily Maximum 8-Hr O_3 During Event (ppb)				2012-2016 Daily Max 8-Hr Avg O_3 Concentration (ppb)		
	5/25/2016	5/26/2016	5/27/2016	5/28/2016	99th %-ile	98th %-ile	97th %-ile
Ancora State Hospital	76	64	61	54	77	74	71
Bayonne	69	76	54	68	76	74	72
Brigantine	79	62	52	45	73	68	66
Camden Spruce St	78	68	59	61	83	78	76
Chester	83	86	64	56	74	71	68
Clarksboro	83	70	59	58	80	77	74
Colliers Mills	90	70	66	62	80	75	72
Columbia WMA	76	73	63	50	69	65	62
Flemington	83	88	69	69	76	73	70
Leonia	86	85	62	77	77	74	72
Millville	81	69	58	52	77	70	68
Monmouth Univ	81	65	49	50	83	73	69
Newark Firehouse	81	77	49	65	75	72	69
Ramapo	79	81	71	55	73	70	68
Rider Univ	82	82	67	70	78	74	71
Rutgers Univ	84	86	75	73	81	76	74
Washington Crossing*	83	86	74	74	78	74	72

*operated by EPA

= or > level of 99th percentile

= or > level of 98th percentile

Figures 67 through 100 are scatter plots of the daily maximum 8-hour ozone concentrations from April 1, 2012 through October 31, 2016. The data for November 1 through March 31 for the intervening years are not included in the plots. A dotted line indicates the level of the 99th percentile concentration for each plot, and a dashed line for the 98th percentile concentration

where applicable. Concentrations from May 25 and May 26, 2016 are highlighted in each plot as a red mark.

Figure 67: Ancora All Daily Maximum 8-Hour Average Ozone Concentrations

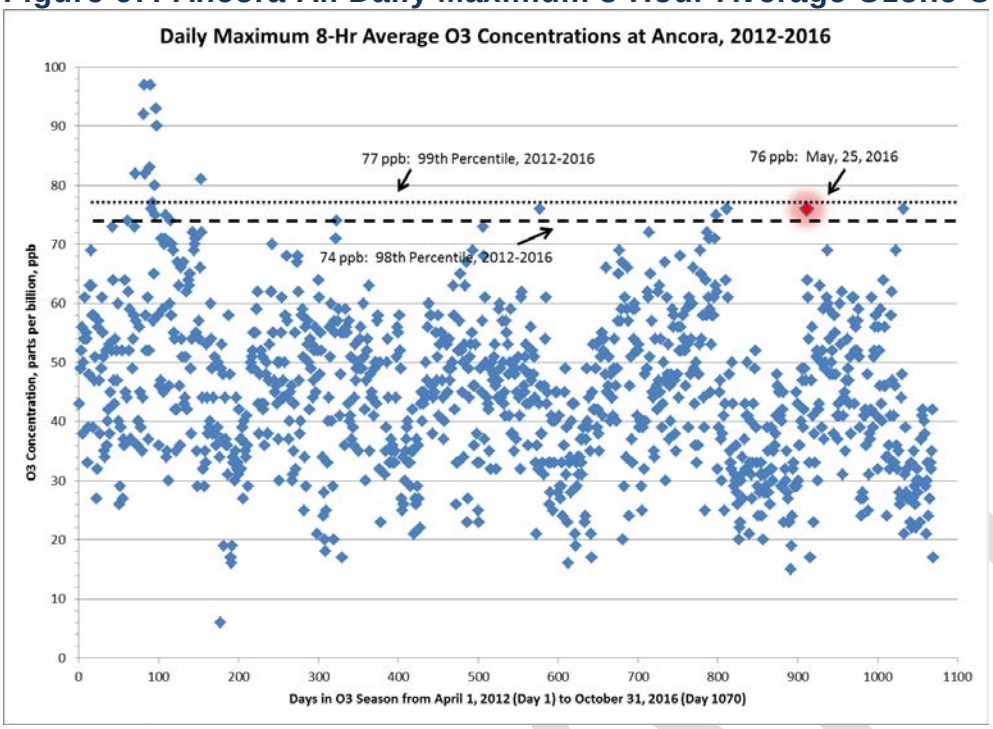


Figure 68: Ancora Yearly Variation in 8-Hour Ozone Concentrations

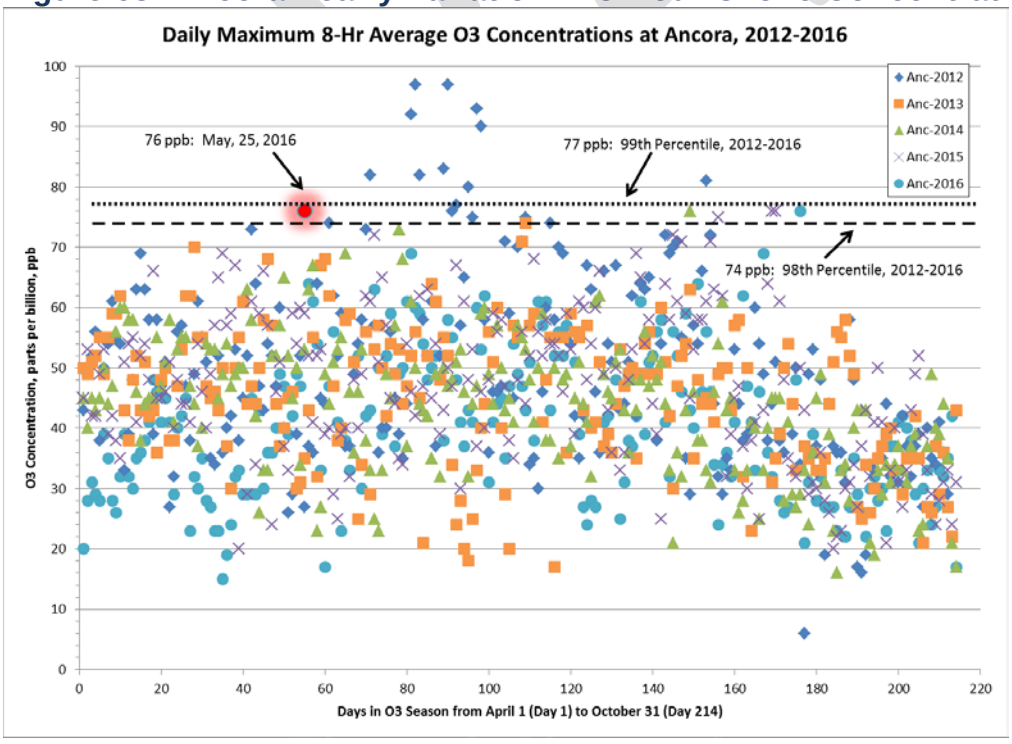


Figure 69: Bayonne All Daily Maximum 8-Hour Average Ozone Concentrations

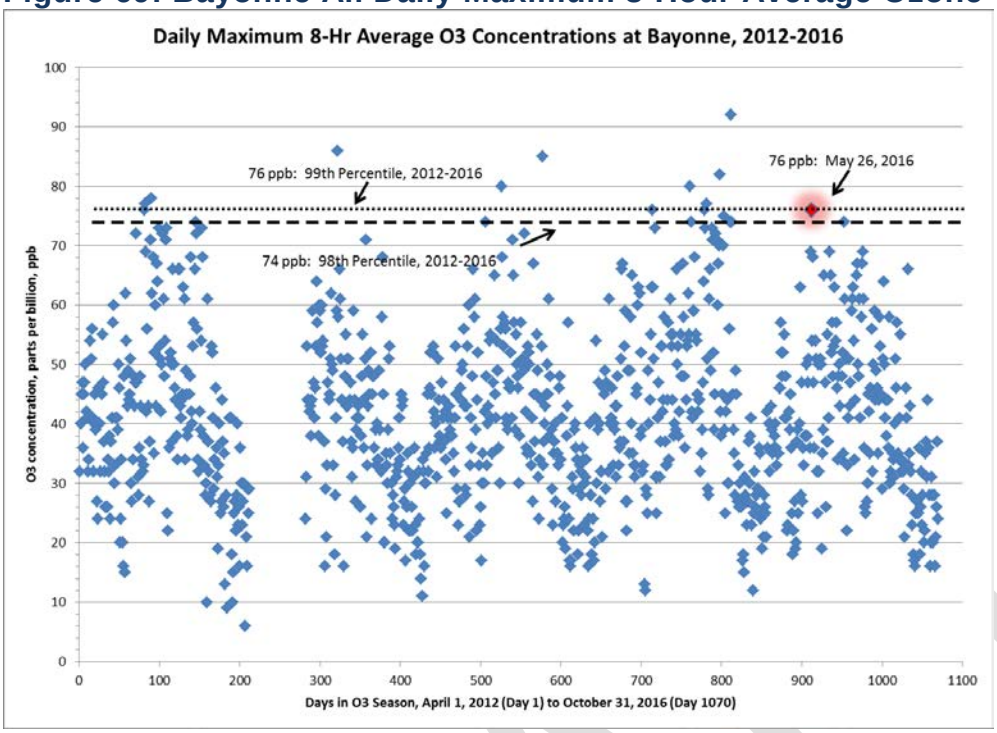


Figure 70: Bayonne Yearly Variation in 8-Hour Ozone Concentrations

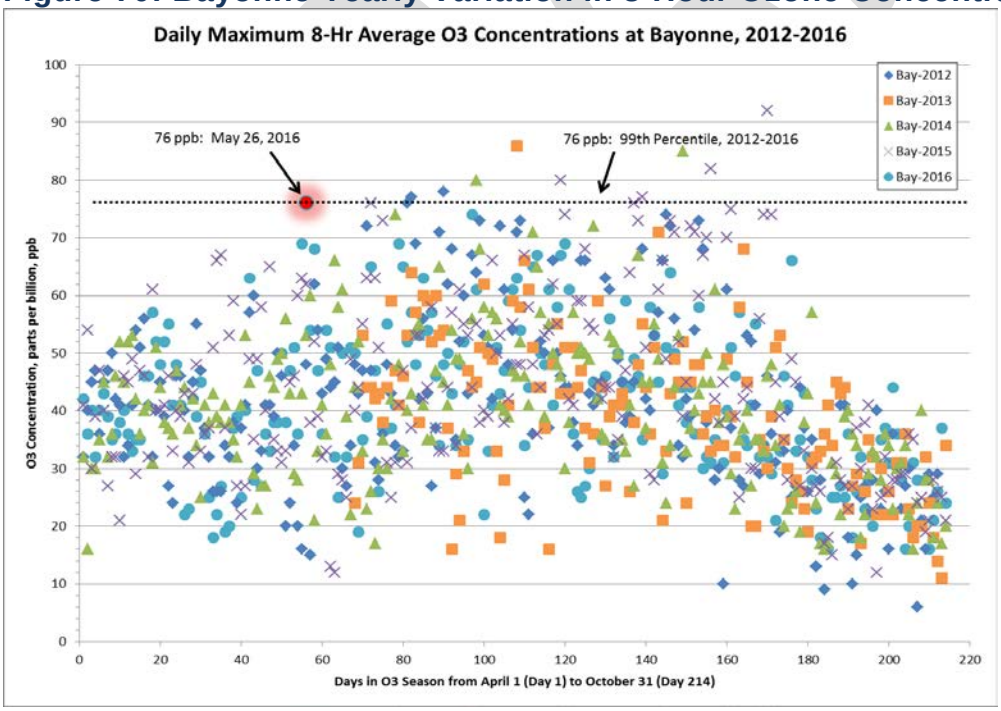


Figure 71: Brigantine All Daily Max. 8-Hour Average Ozone Concentrations

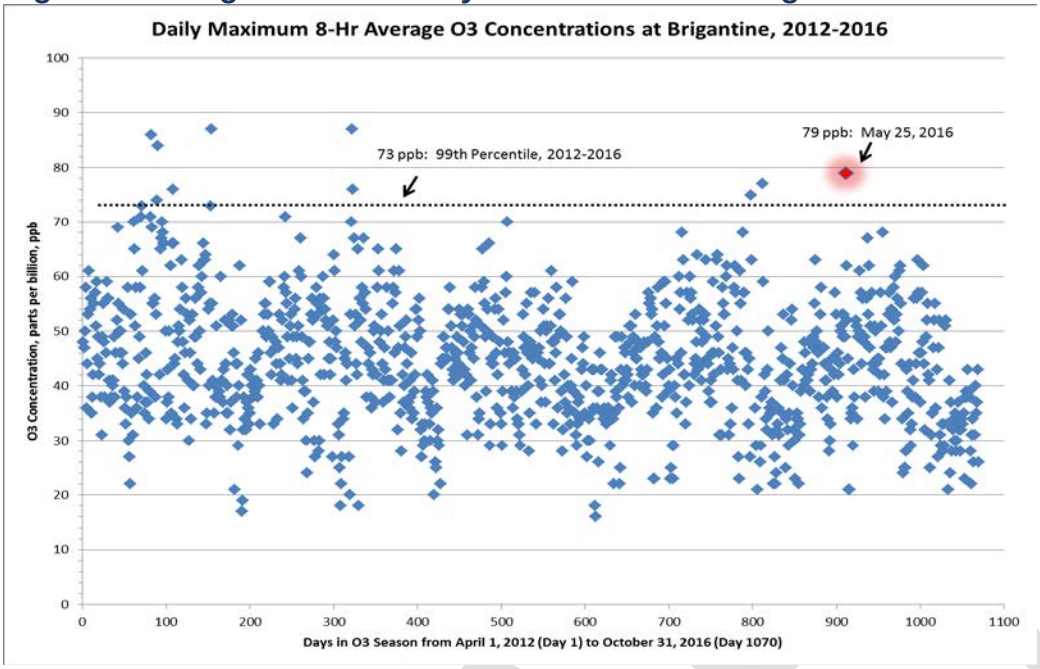


Figure 72: Brigantine Yearly Variation in 8-Hour Ozone Concentrations

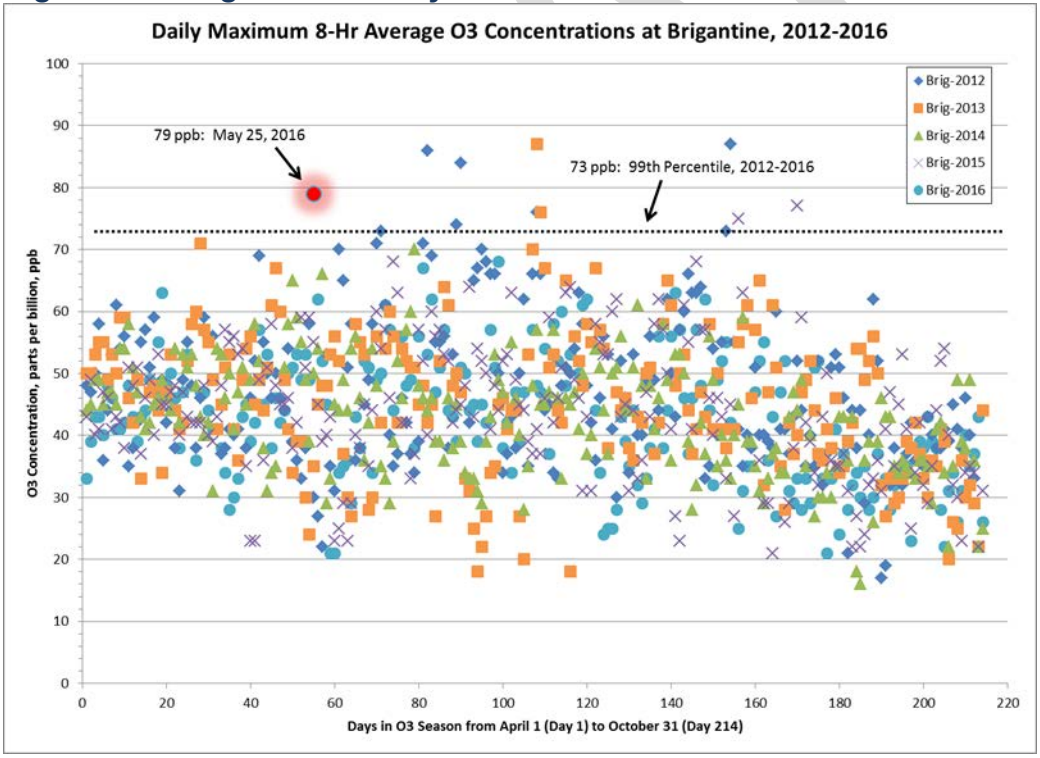


Figure 73: Camden All Daily Maximum 8-Hour Average Ozone Concentrations

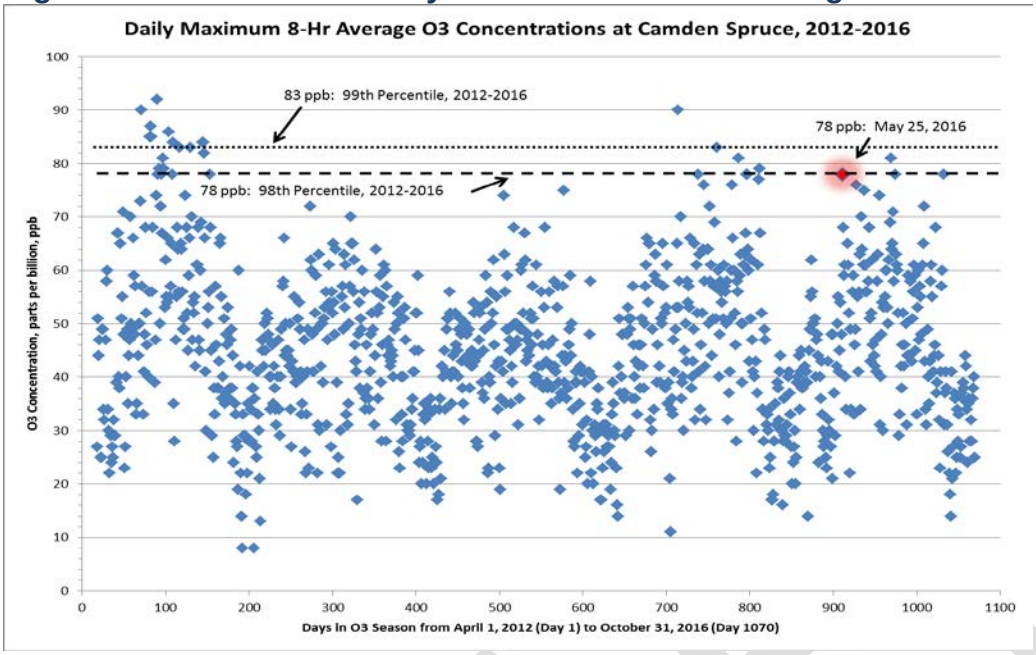


Figure 74: Camden Yearly Variation in 8-Hour Ozone Concentrations

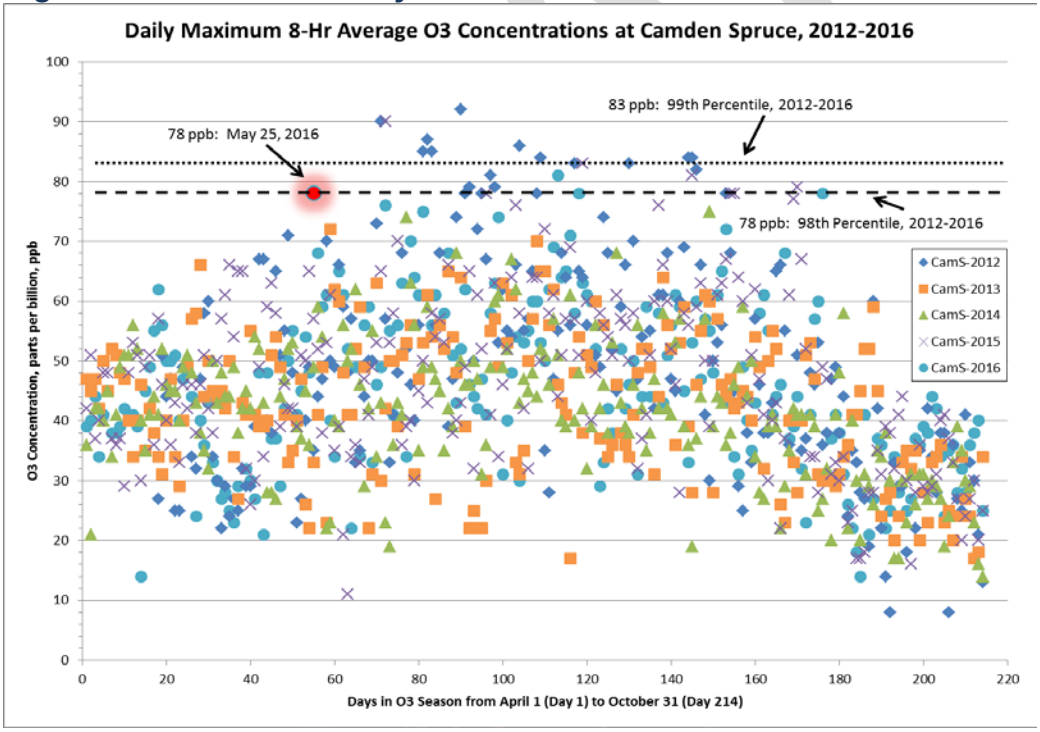


Figure 75: Chester All Daily Maximum 8-Hour Average Ozone Concentrations

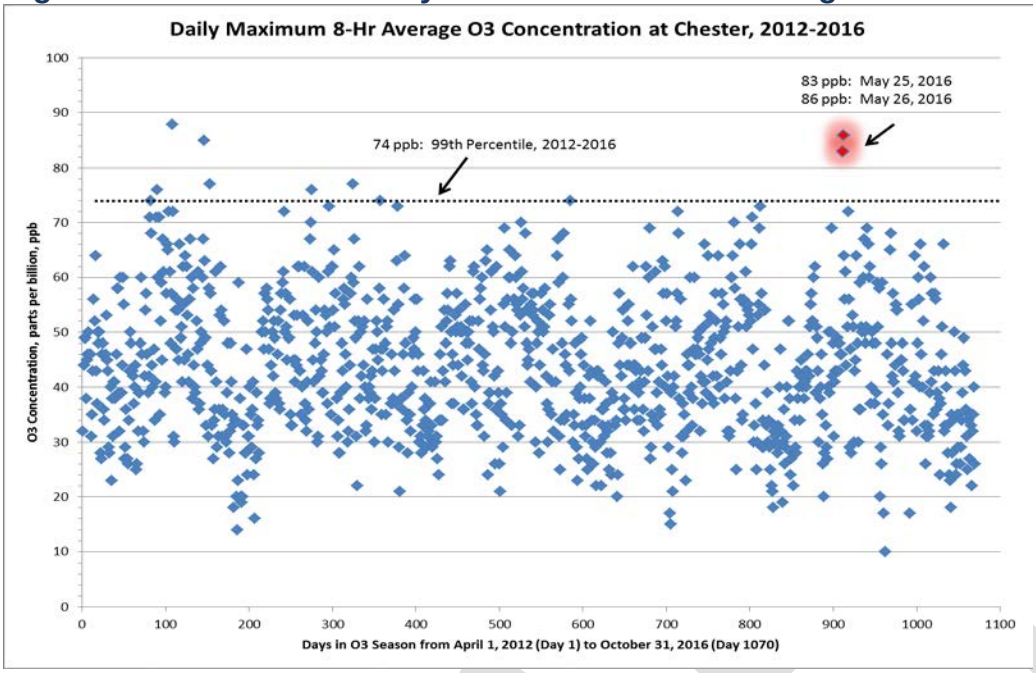


Figure 76: Chester Yearly Variation in 8-Hour Ozone Concentrations

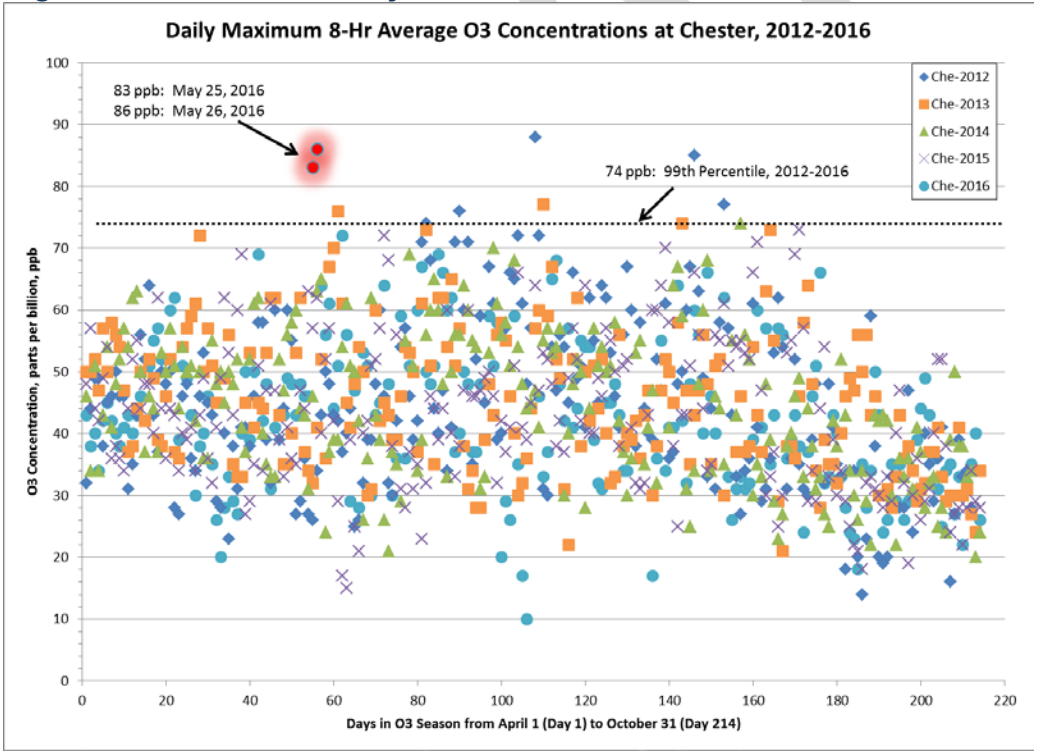


Figure 77: Clarksboro All Daily Max. 8-Hour Average Ozone Concentrations

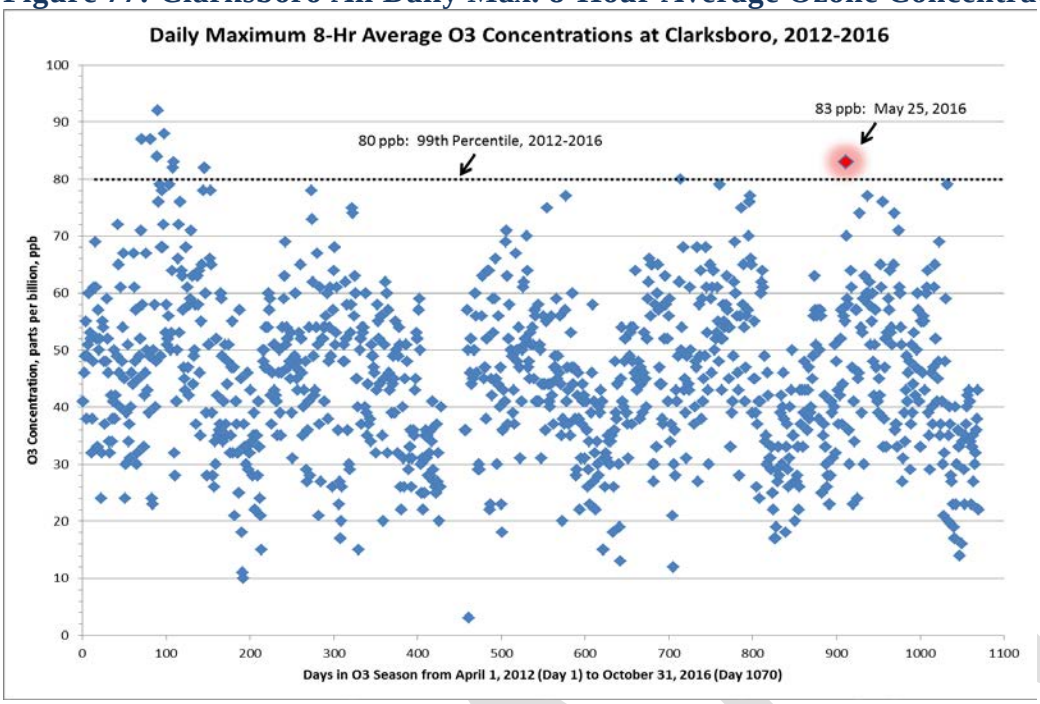


Figure 78: Clarksboro Yearly Variation in 8-Hour Ozone Concentrations

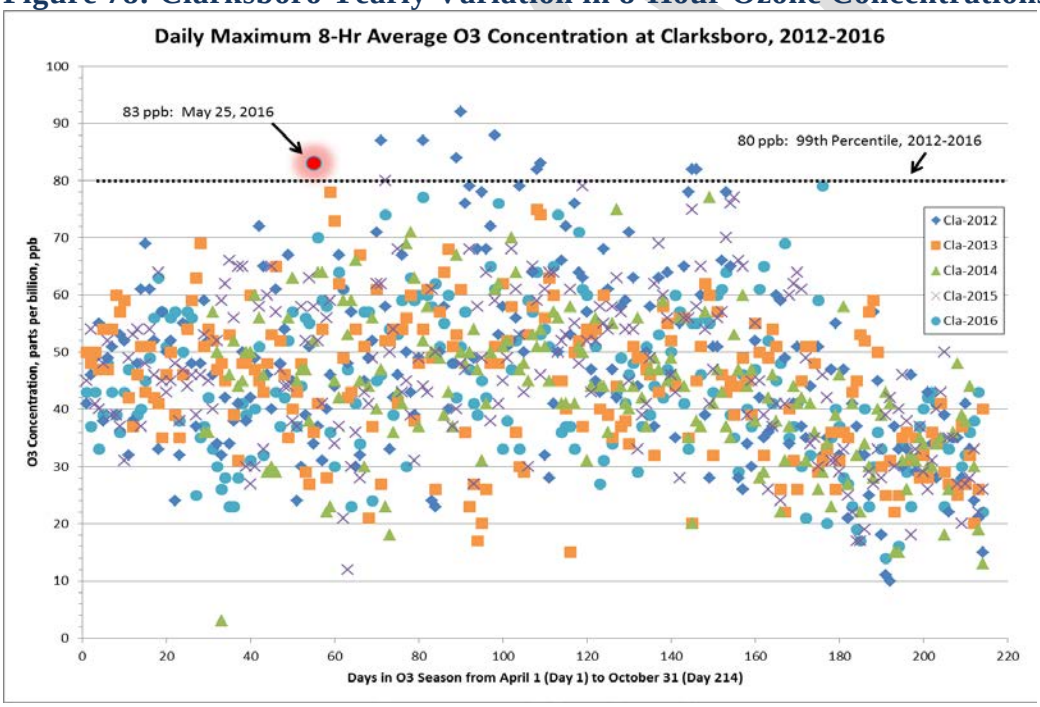


Figure 79: Colliers Mills All Daily Max. 8-Hour Average Ozone Concentrations

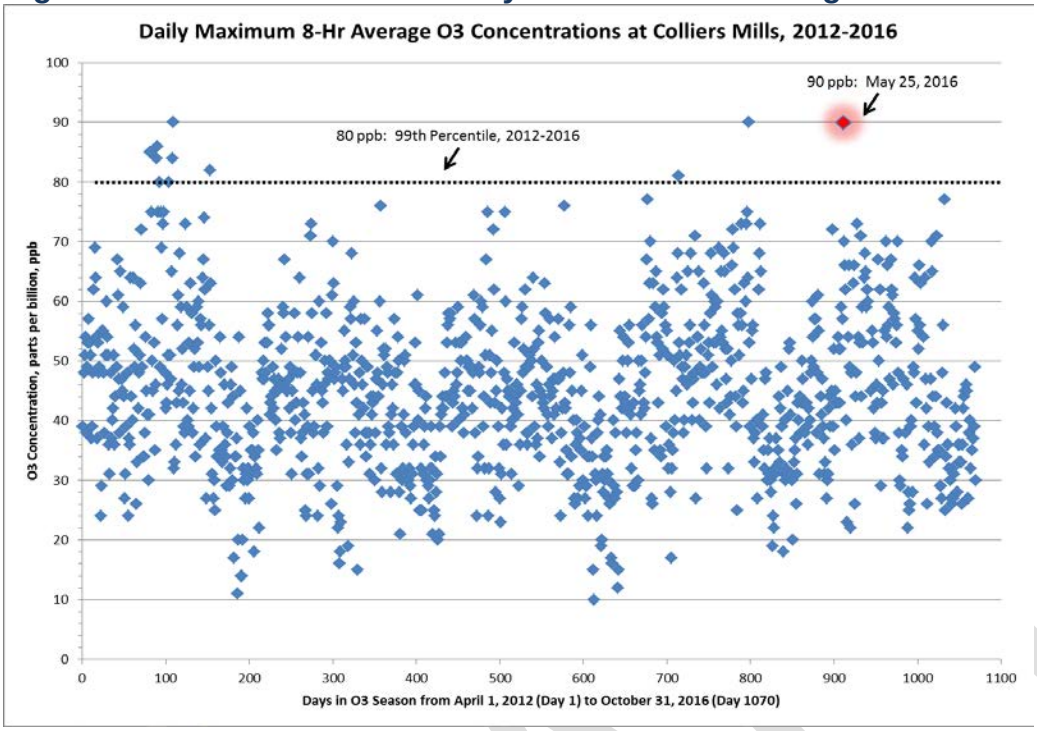


Figure 80: Colliers Mills Yearly Variation in 8-Hour Ozone Concentrations

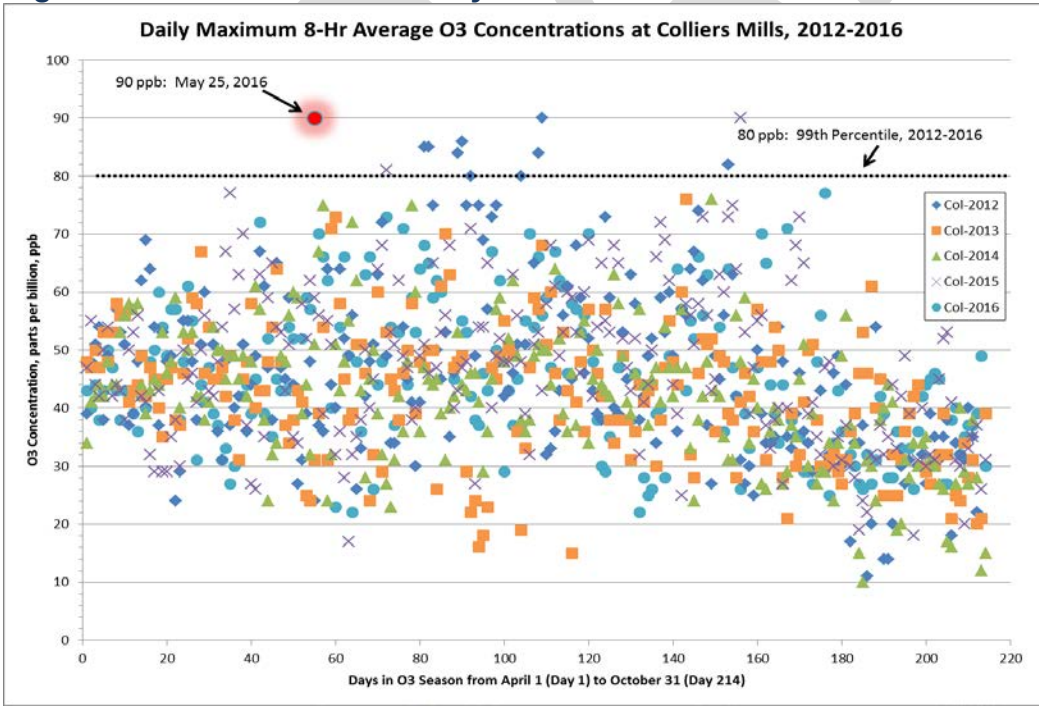


Figure 81: Columbia All Daily Maximum 8-Hour Average Ozone Concentrations

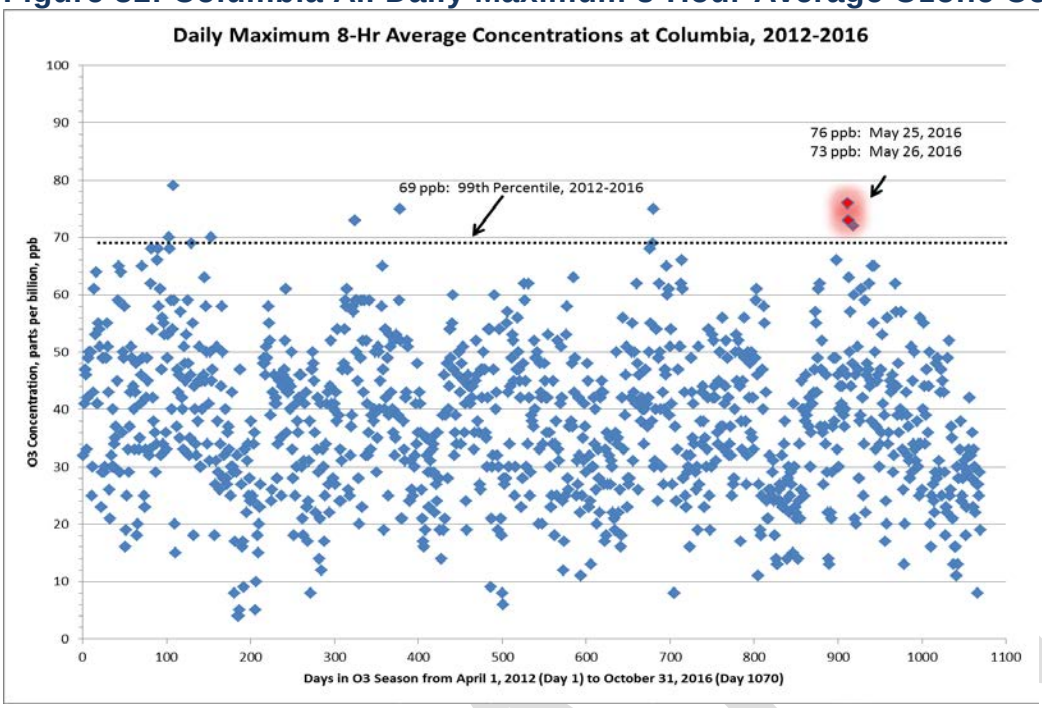


Figure 82: Columbia Yearly Variation in 8-Hour Ozone Concentrations

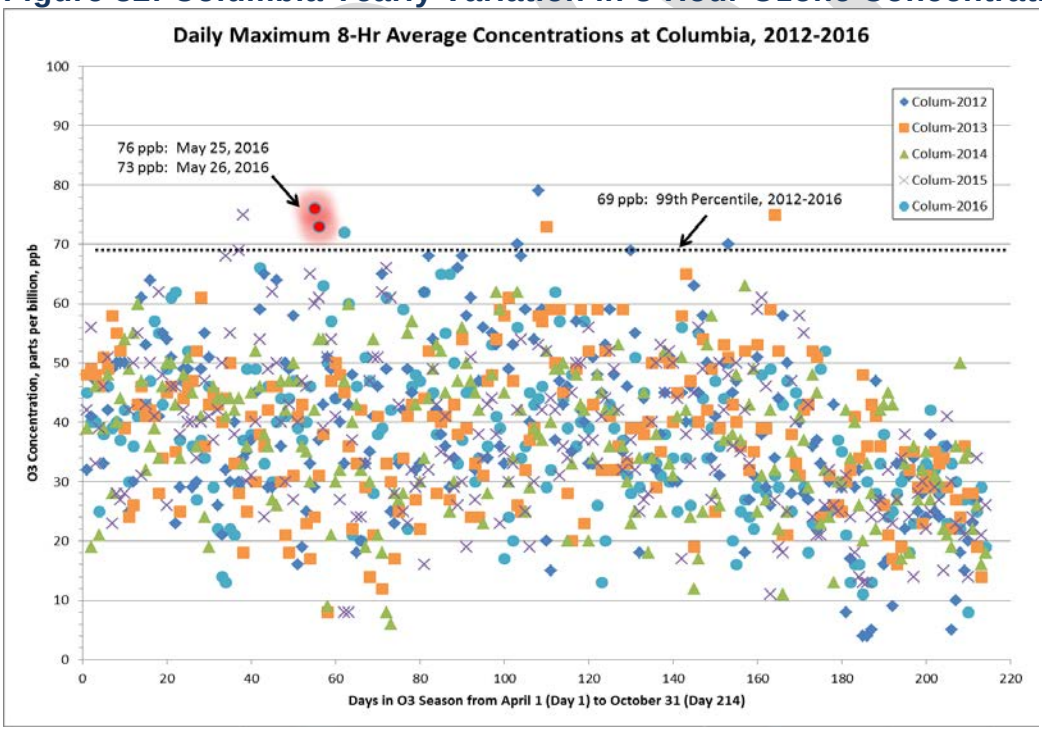


Figure 83: Flemington All Daily Max. 8-Hour Average Ozone Concentrations

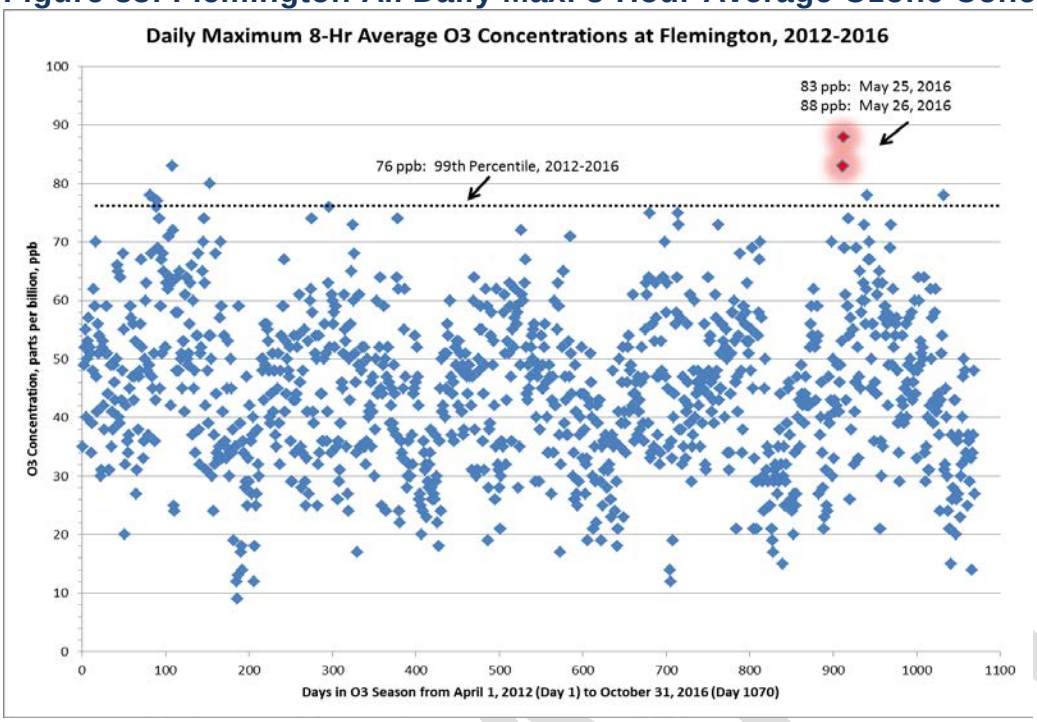


Figure 84: Flemington Yearly Variation in 8-Hour Ozone Concentrations

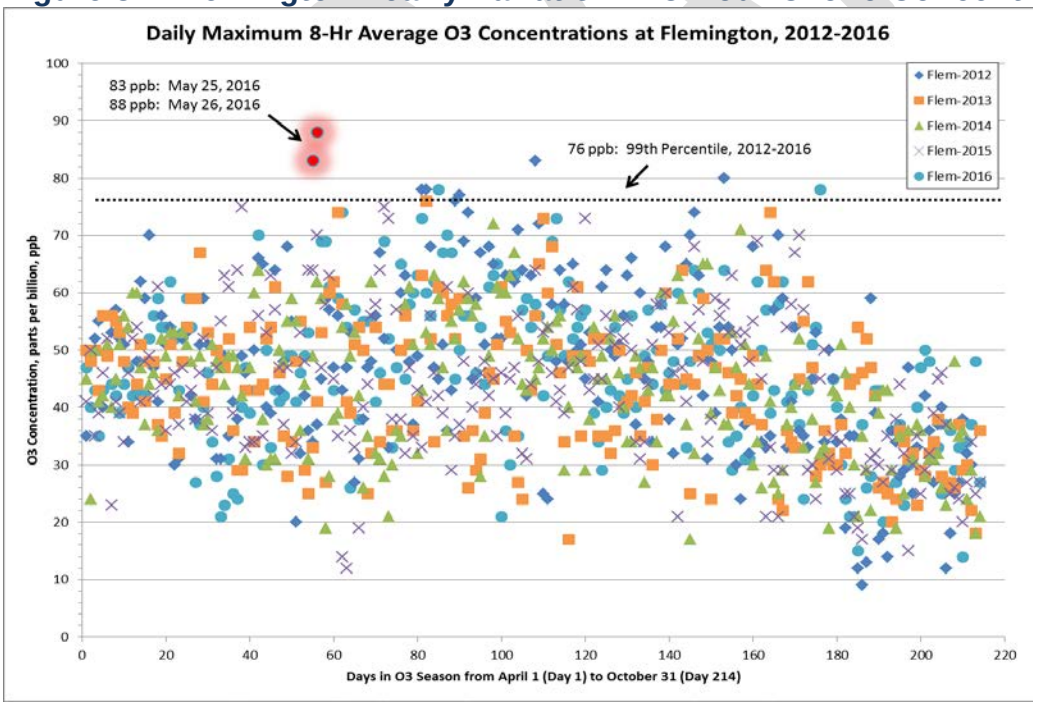


Figure 85: Leonia All Daily Maximum 8-Hour Average Ozone Concentrations

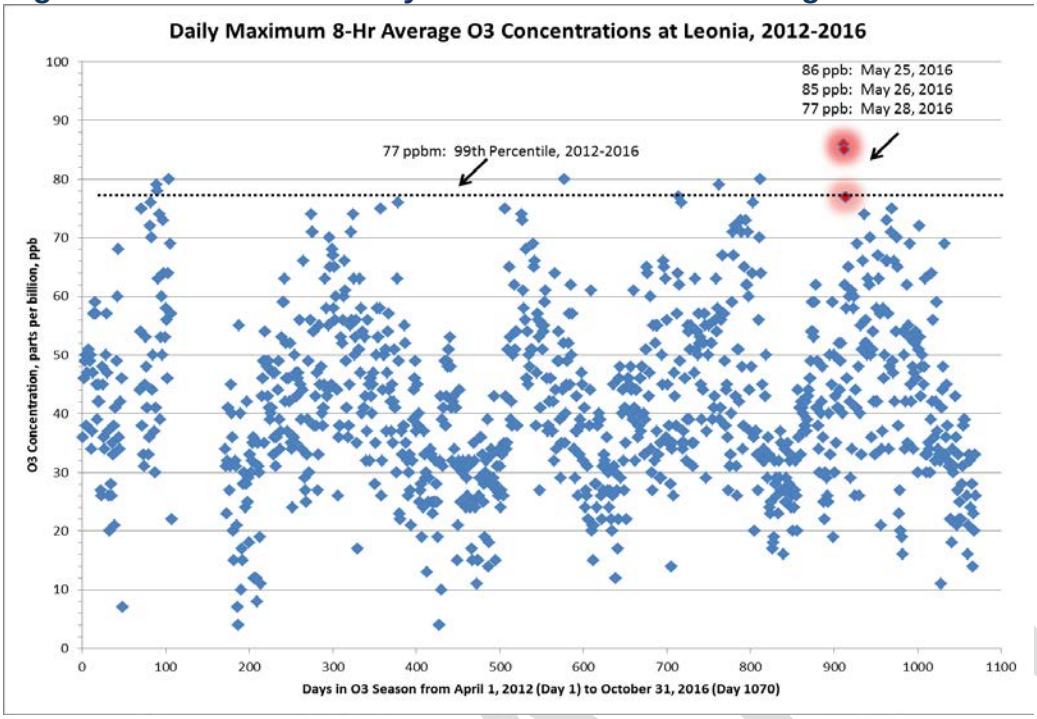


Figure 86: Leonia Yearly Variation in 8-Hour Ozone Concentrations

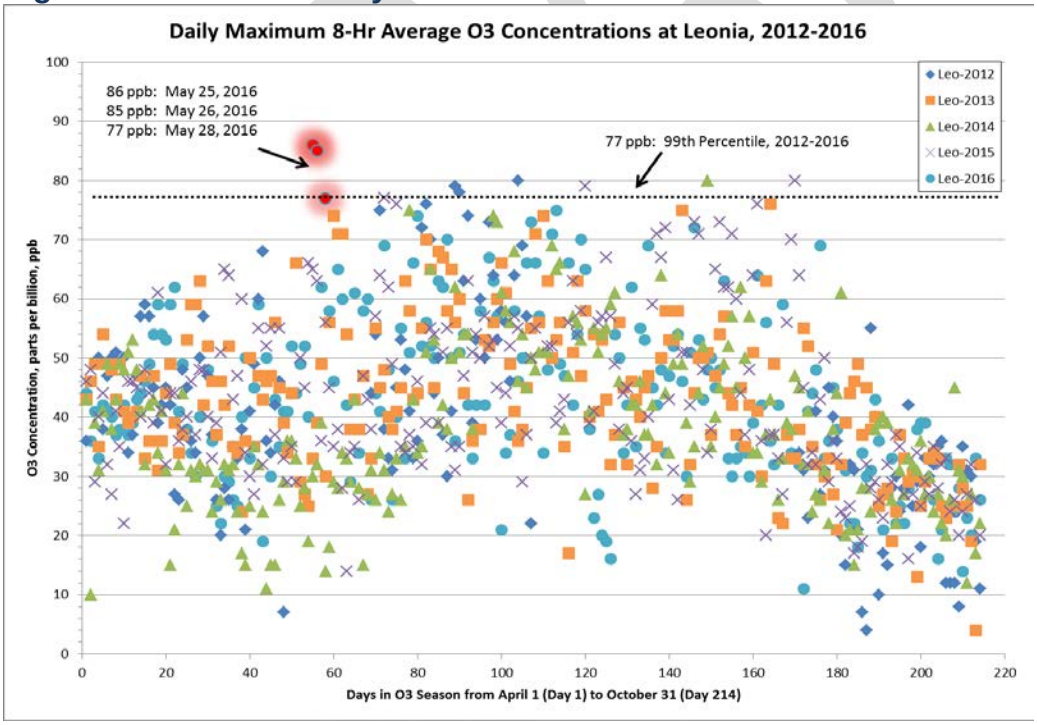


Figure 87: Millville All Daily Maximum 8-Hour Average Ozone Concentrations

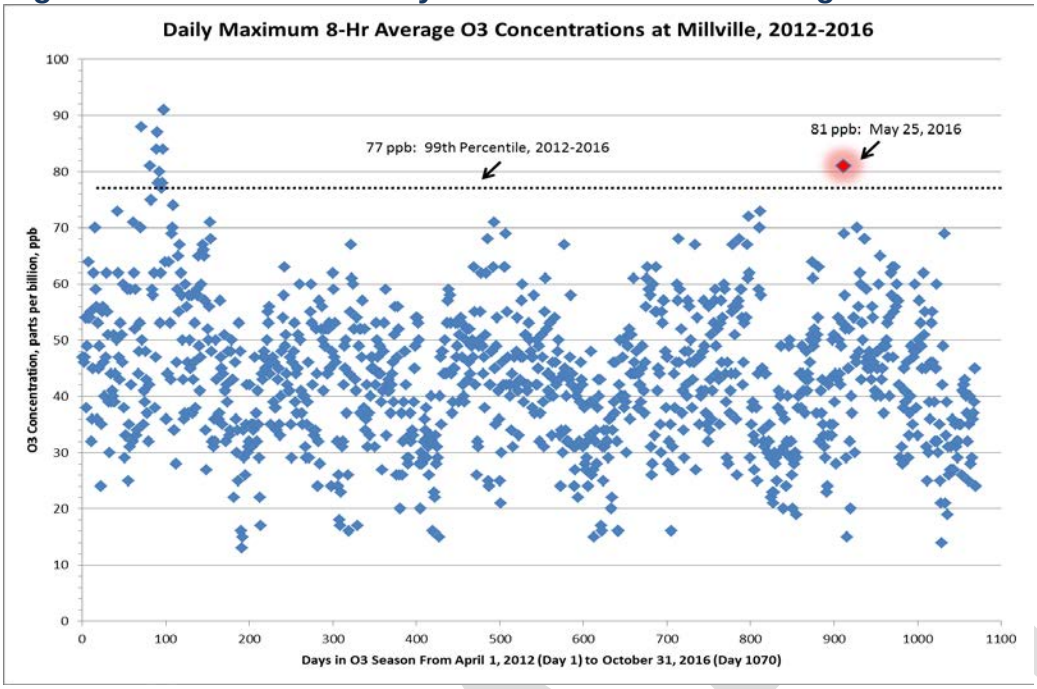


Figure 88: Millville Yearly Variation in 8-Hour Ozone Concentrations

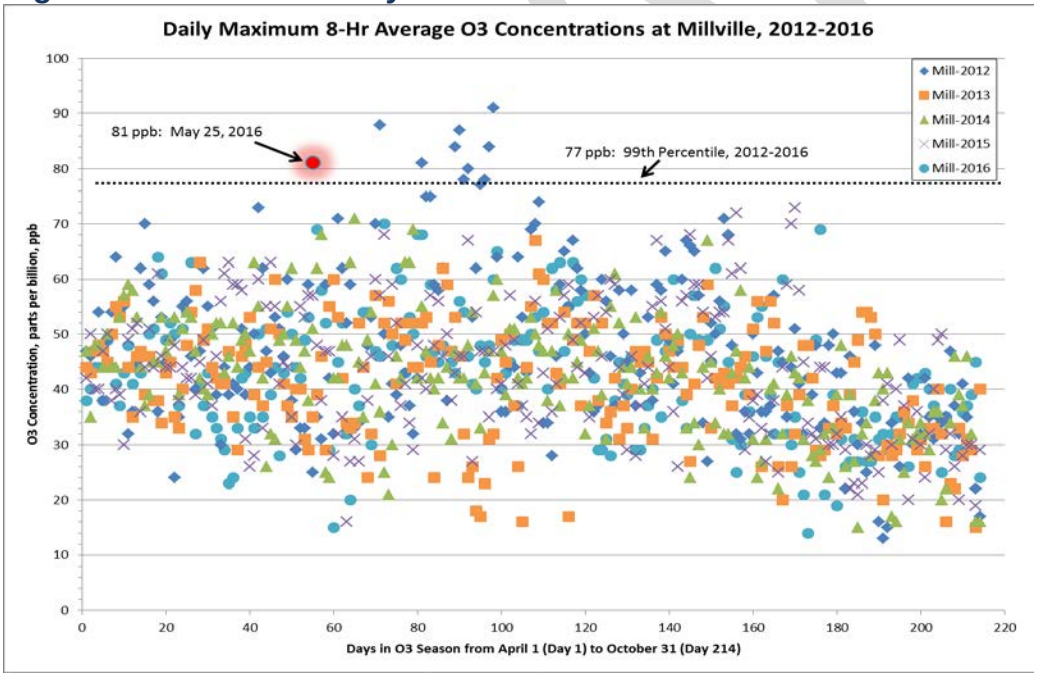


Figure 89: Monmouth U. All Daily Max. 8-Hour Average Ozone Concentrations

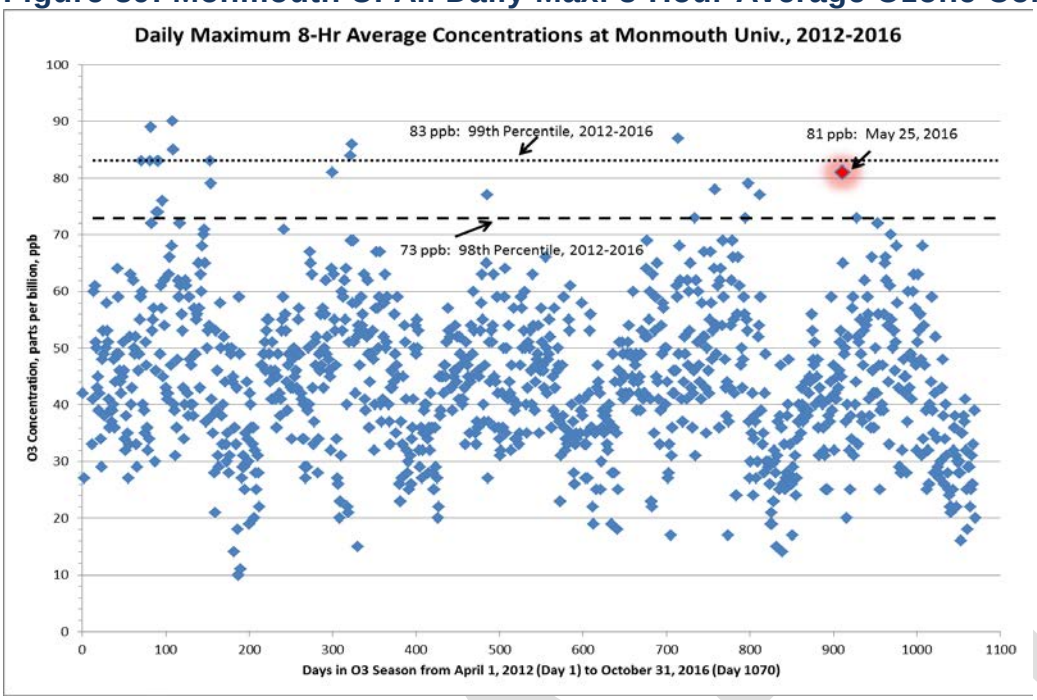


Figure 90: Monmouth U. Yearly Variation in 8-Hour Ozone Concentrations

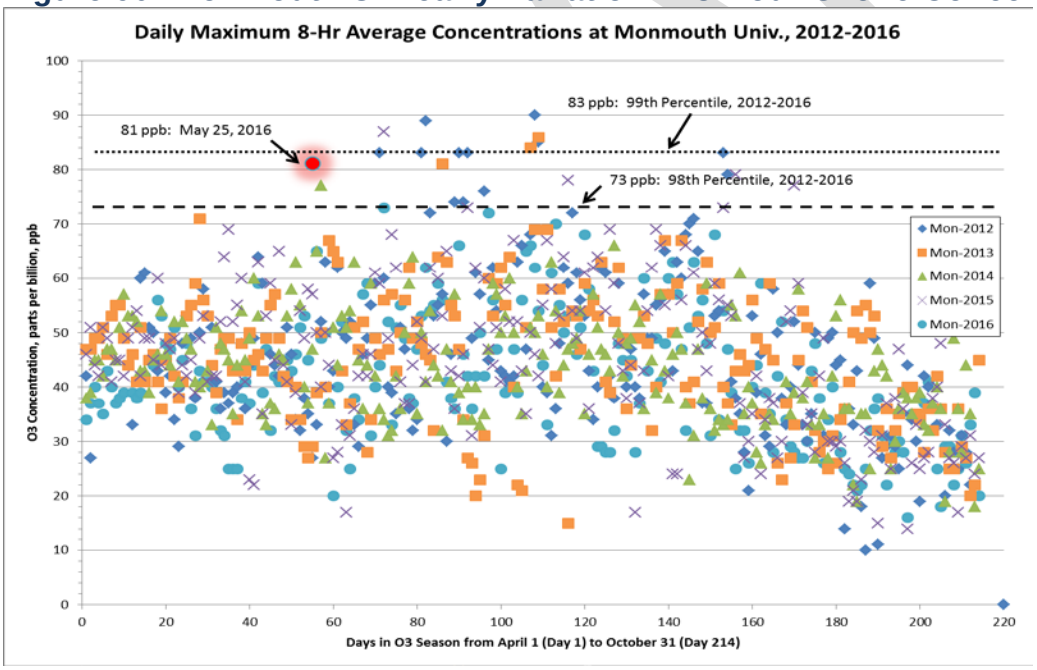


Figure 91: Newark All Daily Maximum 8-Hour Average Ozone Concentrations

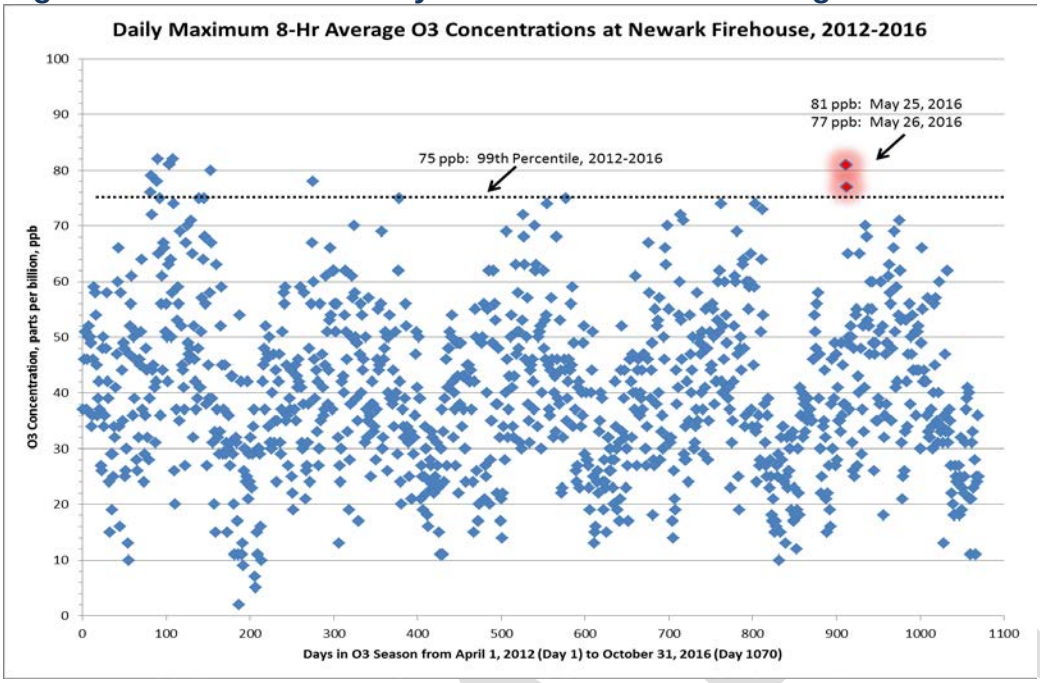


Figure 92: Newark Yearly Variation in 8-Hour Ozone Concentrations

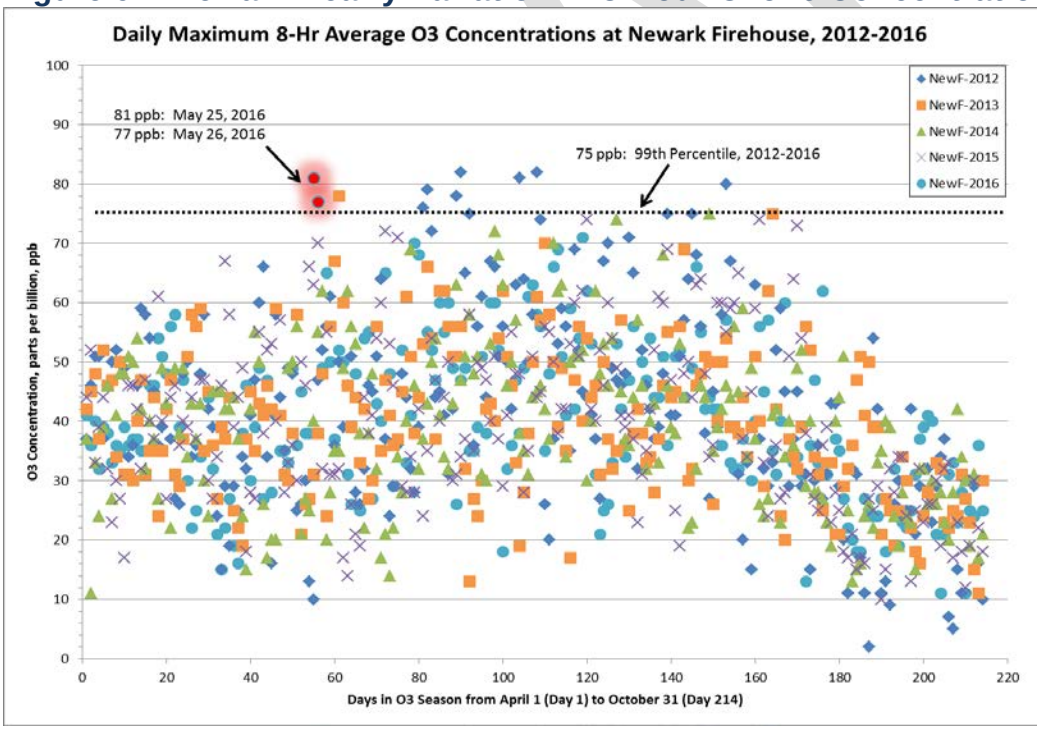


Figure 93: Ramapo All Daily Maximum 8-Hour Average Ozone Concentrations

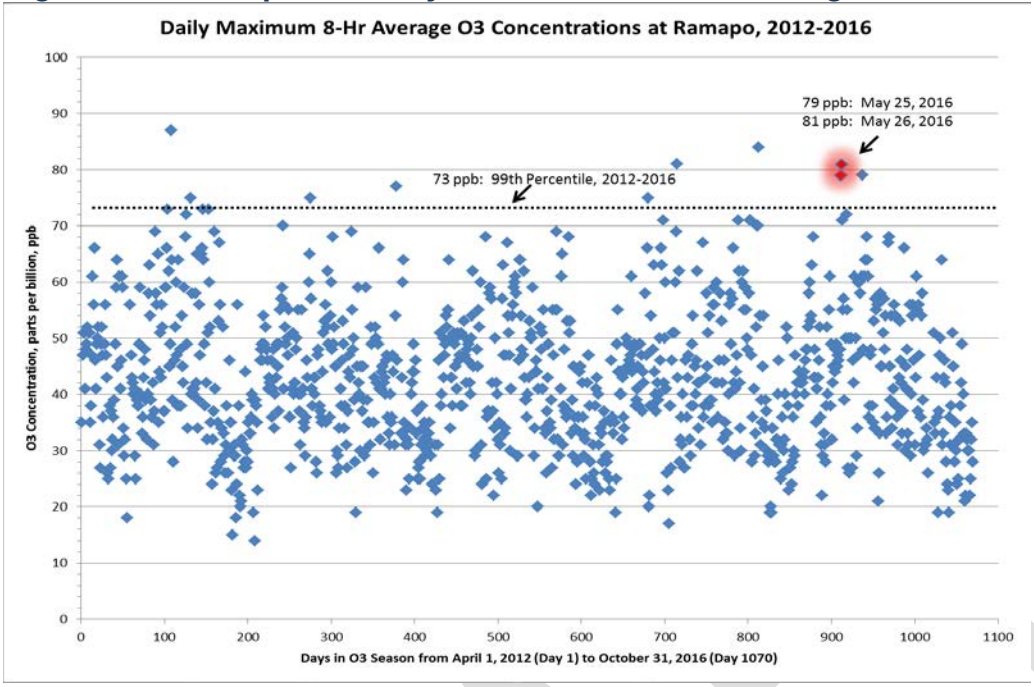


Figure 94: Ramapo Yearly Variation in 8-Hour Ozone Concentrations

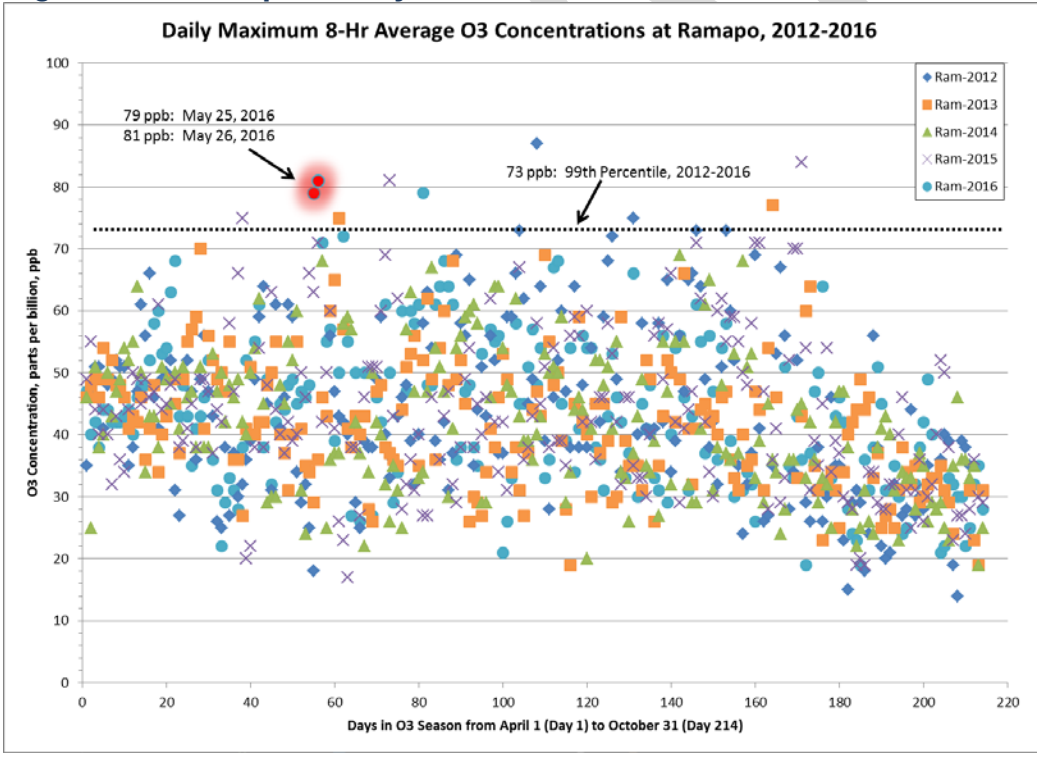


Figure 95: Rider All Daily Maximum 8-Hour Average Ozone Concentrations

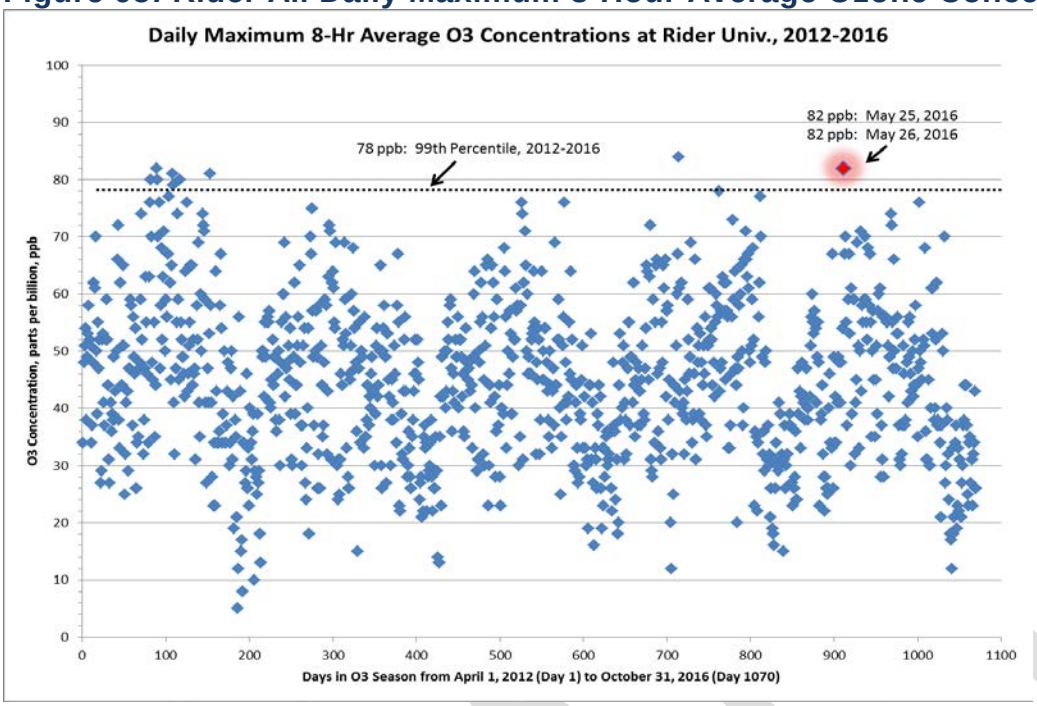


Figure 96: Rider Yearly Variation in 8-Hour Ozone Concentrations

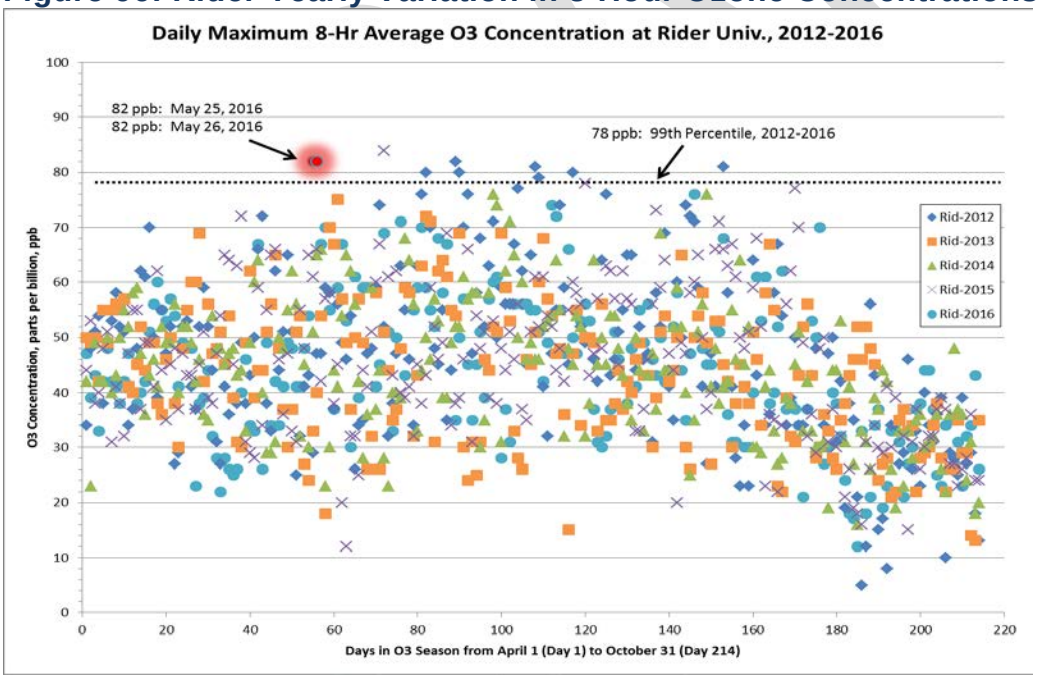


Figure 97: Rutgers All Daily Maximum 8-Hour Average Ozone Concentrations

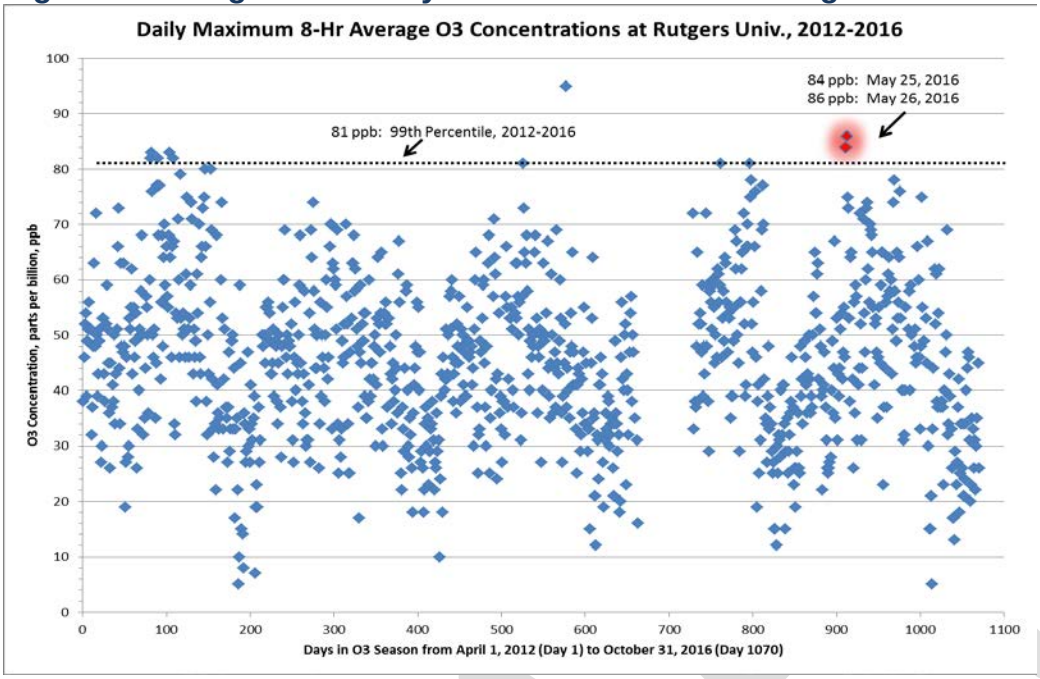


Figure 98: Rutgers Yearly Variation in 8-Hour Ozone Concentrations

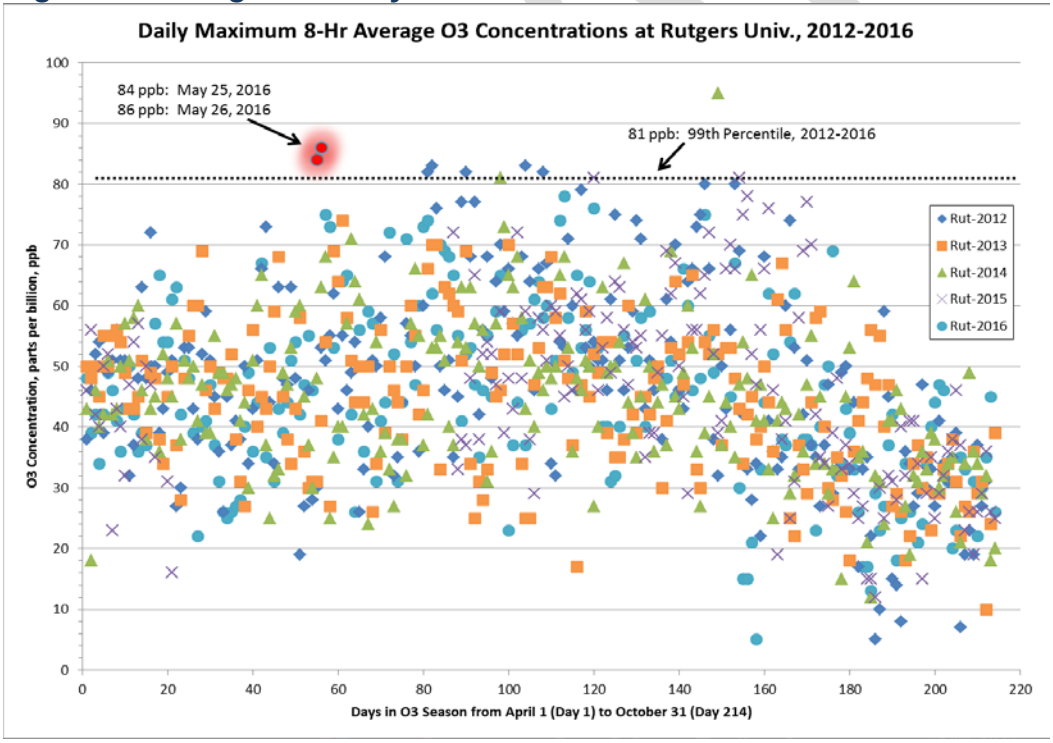


Figure 99: Washington Crossing Daily Max. 8-Hour Avg. Ozone Conc.

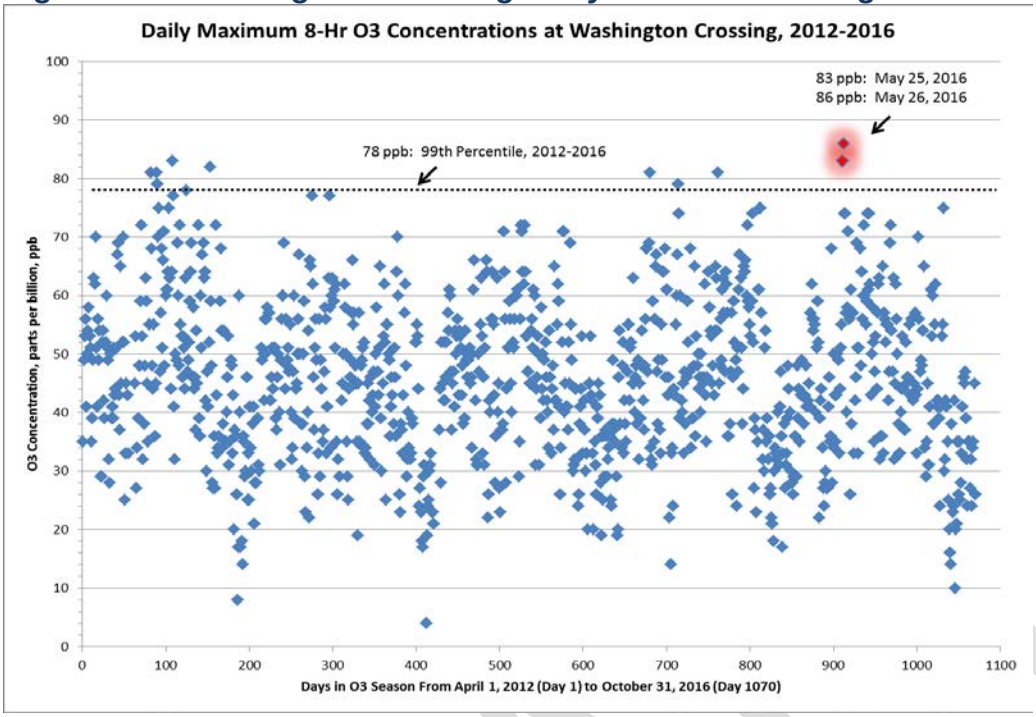
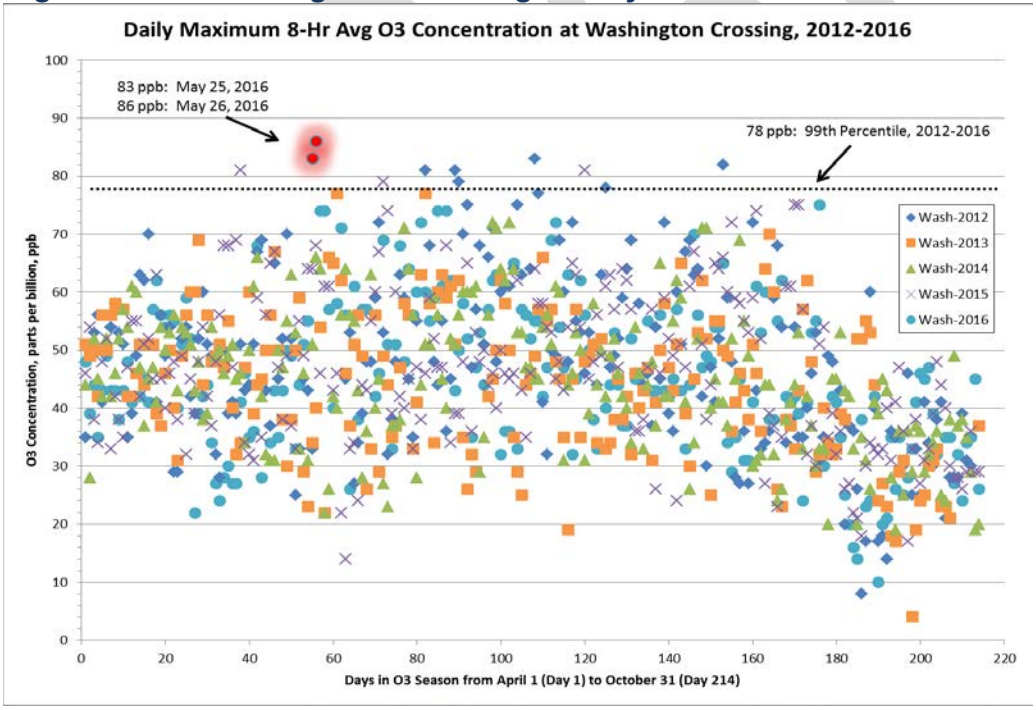


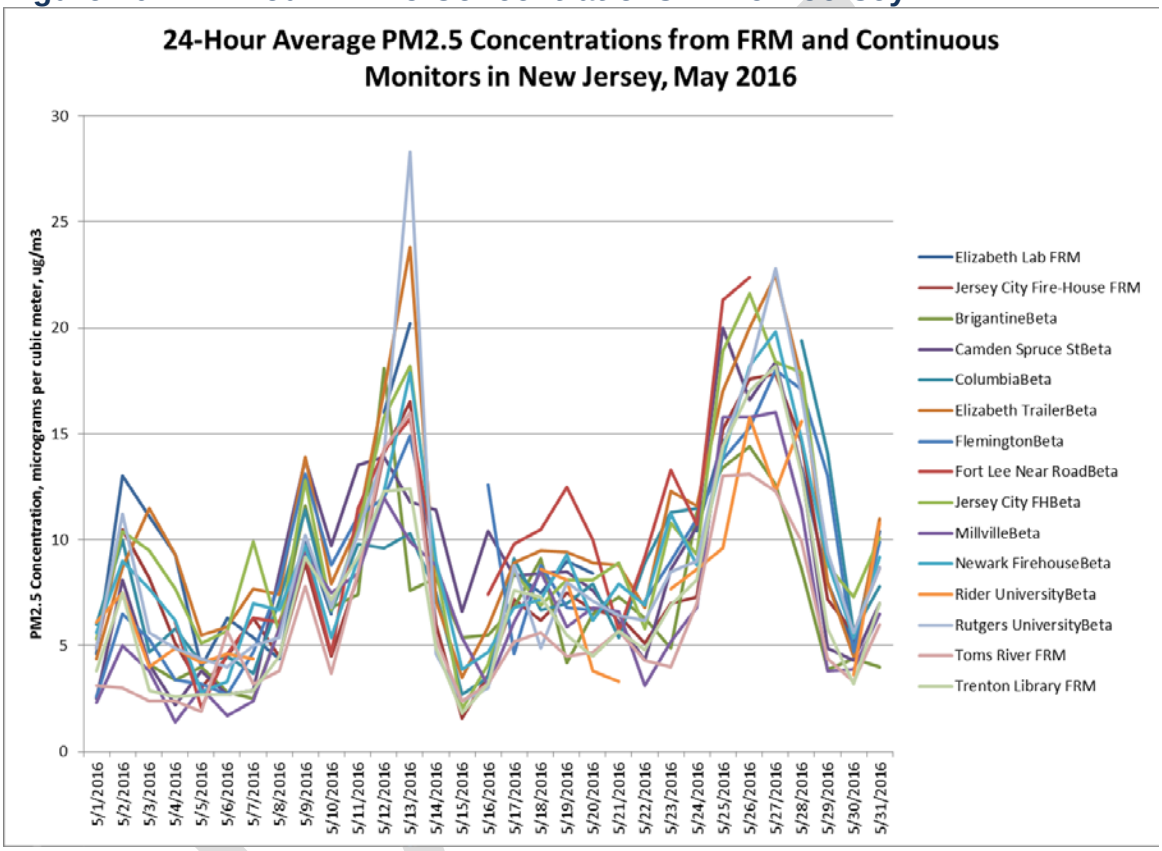
Figure 100: Washington Crossing Yearly Variation in Ozone Concentrations



vii. Discussion of impact of Canadian fire on PM2.5 concentrations in New Jersey

PM2.5 emissions from wildfires can be transported across large distances. Figure 101 presents the 24-hour average PM2.5 concentrations measured in May 2016 from filter-based Federal Reference Method (FRM) and continuous Federal Equivalent Method (FEM) monitors in New Jersey. Figure 101 indicates that elevated PM2.5 concentrations were measured from May 25 through May 28, 2016 throughout New Jersey, and these concentrations were coincident with the elevated ozone concentrations.

Figure 101: 24-Hour PM2.5 Concentrations in New Jersey



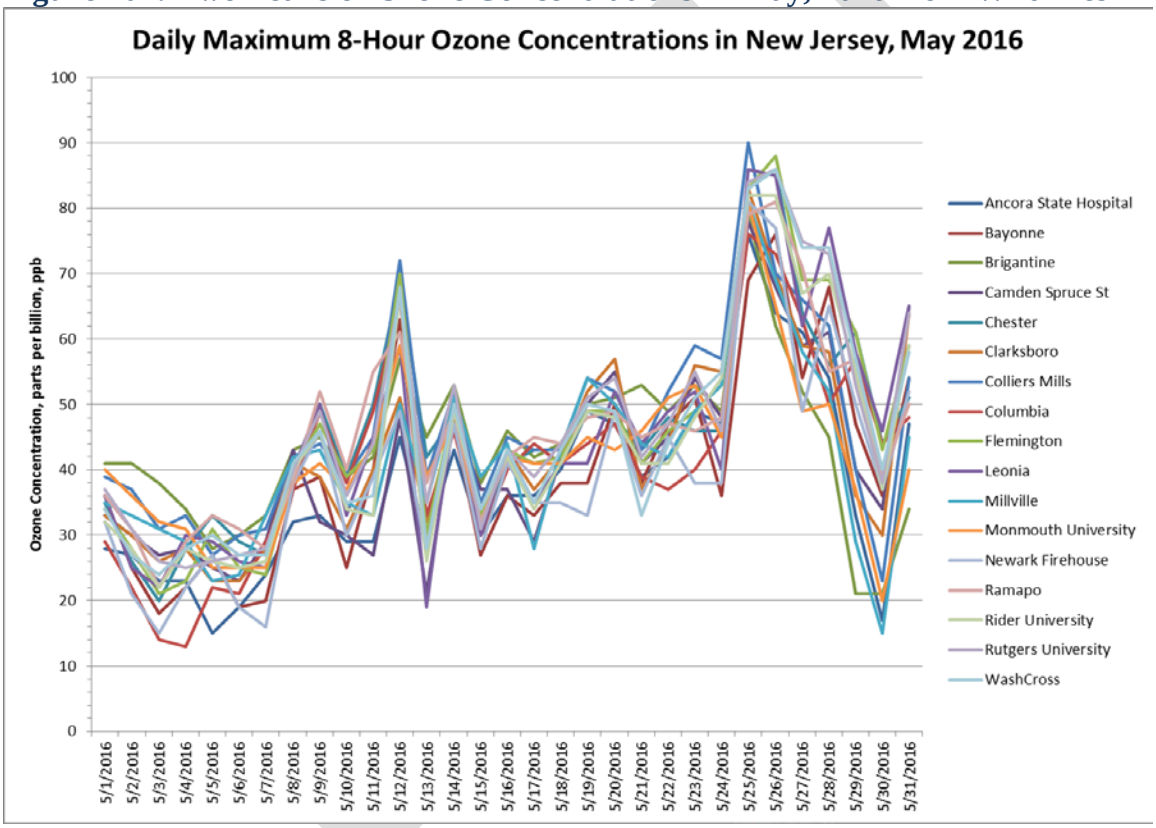
viii. Discussion of impact of local wildfire to ozone and PM2.5 concentrations

New Jersey had coincidentally been influenced by a local wildfire earlier in May, 2016 that was different than the Canadian wildfire but also influenced PM2.5 and ozone levels in New Jersey and Connecticut. Figure 102 presents the daily maximum 8-hour ozone concentrations measured in May 2016 from the seventeen ozone monitors in New Jersey. Evident in both Figure 101 and Figure 102 is a peak in PM2.5 concentrations and ozone concentrations on May 12, 2016. These elevated concentrations are attributed to the "Henry Wildfire" that began on May 12, 2016 in a portion of the Bass River State Forest in Bass River Township in Burlington County, NJ. The wildfire, which spread across 464 acres, was documented in an internal New Jersey Department

of Environmental Protection (NJDEP) Emergency Operations Situation Report and in the local press.[22]

The wildfire was located approximately ten miles north of Atlantic City, where Burlington, Ocean, and Atlantic Counties converge. Wind direction measurements from NJDEP sensors indicated that the winds on May 12, 2016 ranged from southeasterly to southwesterly. As a result, the winds carried the smoke plume across central and northern New Jersey. The maximum temperatures were unseasonably warm for early May, ranging from 72 to 79 degrees Fahrenheit, and solar radiation was strong due to clear skies. The Colliers Mills station, which is directly downwind from the Henry Wildfire, exceeded the 70 ppb NAAQS on May 12, 2016 with a daily maximum 8-hour ozone concentration of 72 ppb. The impact of the wildfire reached Connecticut where the Middletown station measured 71 ppb.

Figure 102: Two Peaks of Ozone Concentrations in May, 2016 from Wildfires



[22] http://www.nj.com/burlington/index.ssf/2016/05/large_forest_fire_burning_in_bass_river_state_fore.html; http://www.nbcphiladelphia.com/news/local/200-Acres-Burn-in-Burlington-County-Forest-Fire-379286791.html; http://www.pressofatlanticcity.com/news/bass-river-fire-burns-more-than-acres/article_b9dd11d8-1900-11e6-bf8b-6fd112063cc4.html

ix. Evidence that the fire emissions were transported to the monitors trajectory analysis

Wind trajectories for the period of the exceptional event (May 25 and 26, 2016) were from the direction of the Fort McMurray fire in Alberta, Canada. Figures 103 and 104 are wind trajectories from May 25 and 26, 2016 as determined from the NOAA HYSPLIT model. Colliers Mill, NJ was selected as the site for determining where the air flow originated on the day of the event because it was the monitor recording the highest 8-hour ozone levels in the State on May 25, 2016. These wind directions are consistent with the satellite observations previously presented.

Figure 103: 48 Hour Backward Trajectories Ending at 2000 UTC 25 May 16

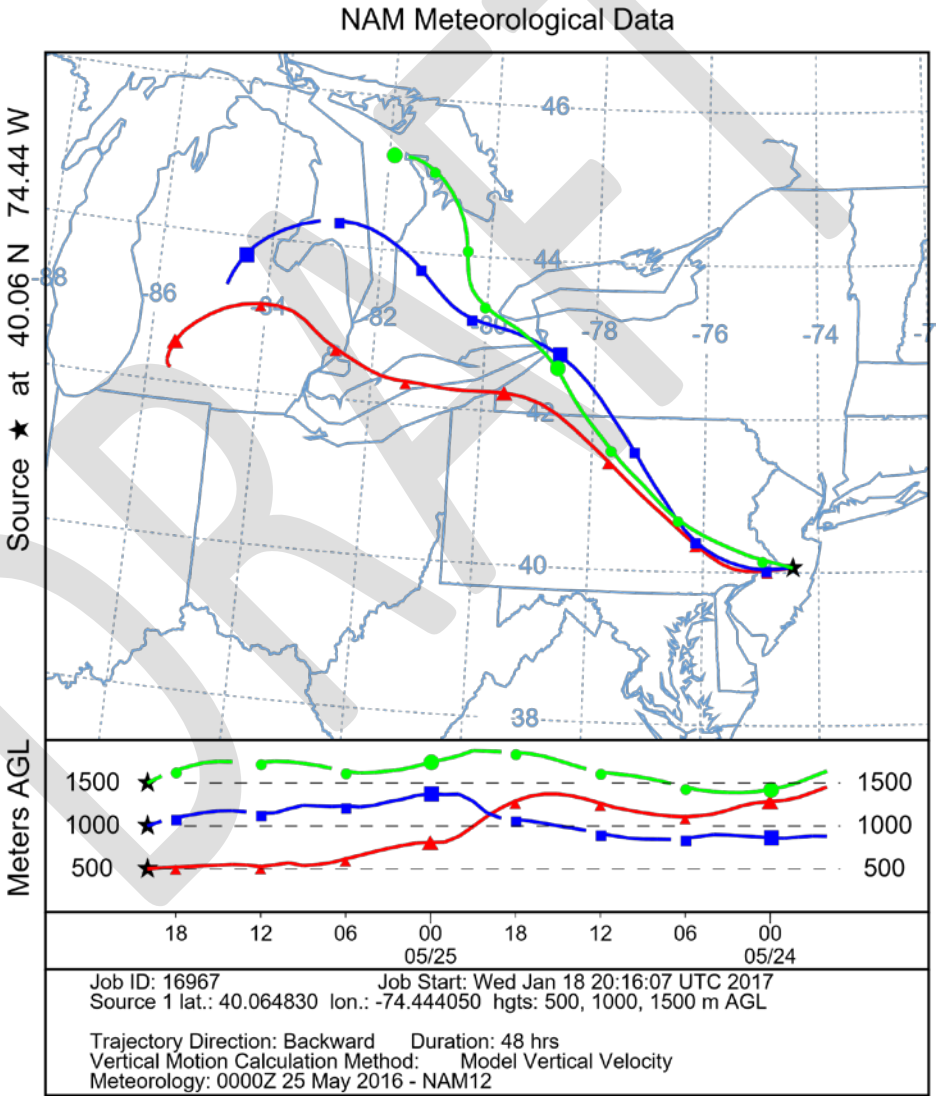
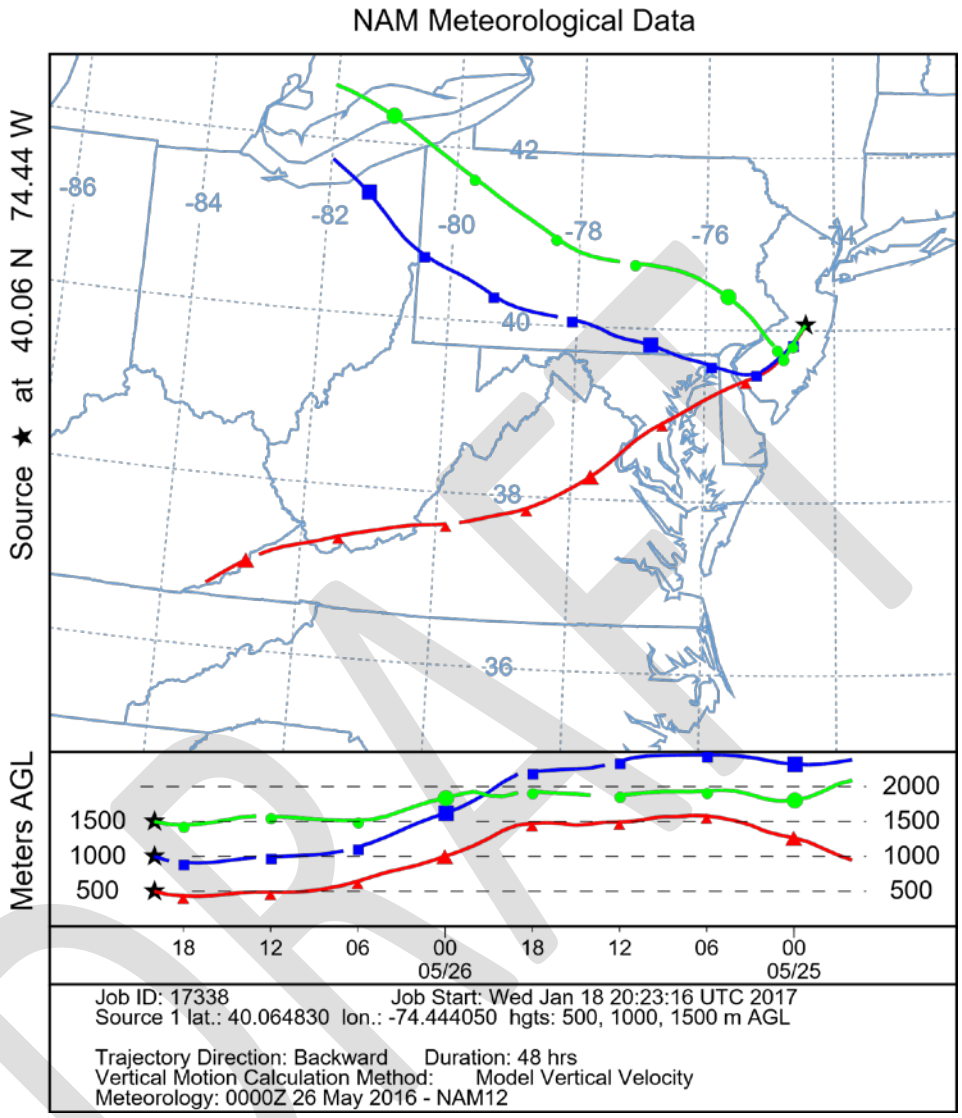


Figure 104: 48 Hour Backward Trajectories Ending at 2000 UTC 26 May 16



Long range wind trajectories for the period of the exceptional event (May 25 and 26, 2016) were from the direction of the Fort McMurray fire in Alberta, Canada as shown in Figure 105 and 106. Atmospheric heights of 500, 1500 and 2000 meters were chosen due to the elevated ozone levels occurring along the trajectory path. Figure 105 is a 150-hour backward trajectory path of where the air in New Jersey on May 25th originated. This trajectory shows a path of the air mass traveling through Canada and Michigan into New Jersey. Also, shown in Figure 105, the kink in the trajectory in Michigan is an example of how the air mass stalled over that region for several days. In addition, the elevated air that started in Alberta, Canada was at an elevation of 3000 – 4000m; as it traveled further eastward, the trajectory shows the air aloft migrated down to lower levels of the atmosphere in the 500 – 1500m range as shown in Figure 105. Figure 106 is a 150-hour forward trajectory of where the air in Alberta Canada traveled to after May 20, 2016. Figures 105 and 106 are trajectories created by the NOAA HYSPLIT model with starting location at Colliers Mills, NJ (Figure 105) and Fort McMurray, Alberta, Canada (Figure 106). The wind trajectories are consistent with previous 48-hour trajectories and satellite imagery.

Figure 105: 150 Hour Backward Trajectories Ending at 2000 UTC 25 May 16

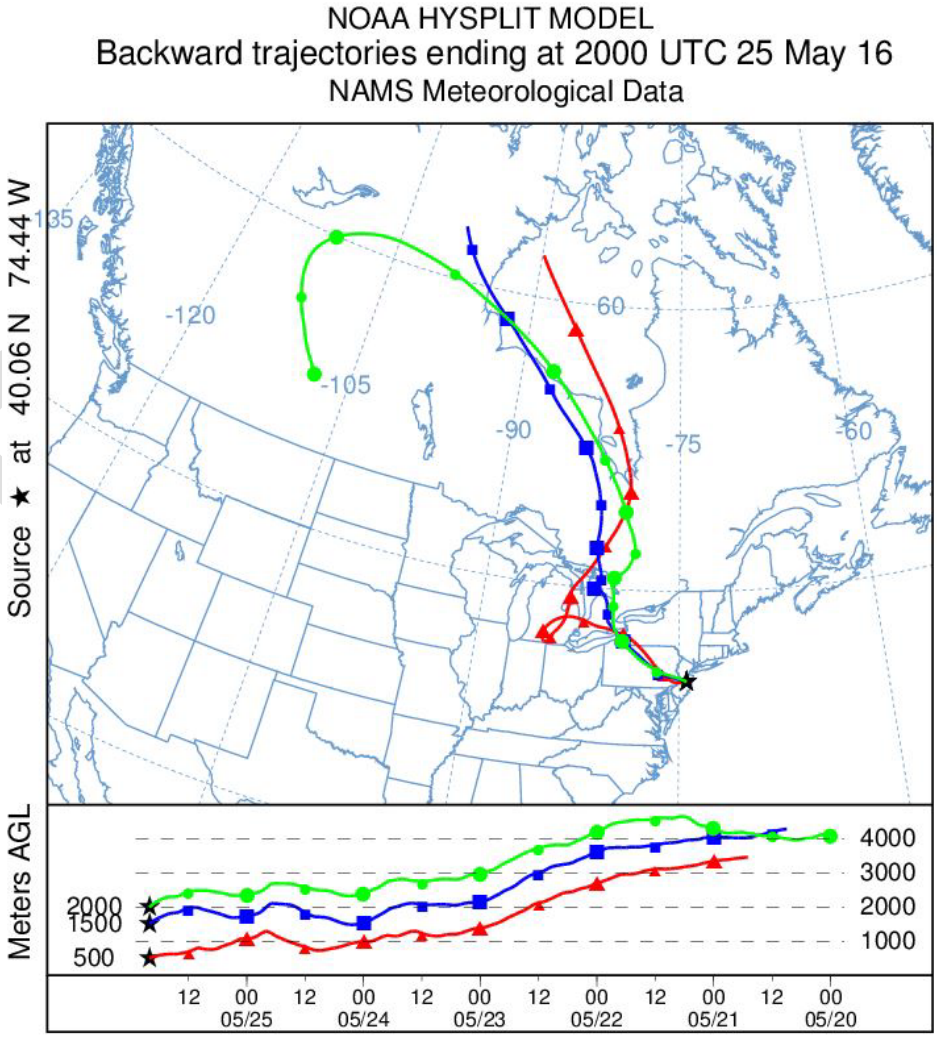
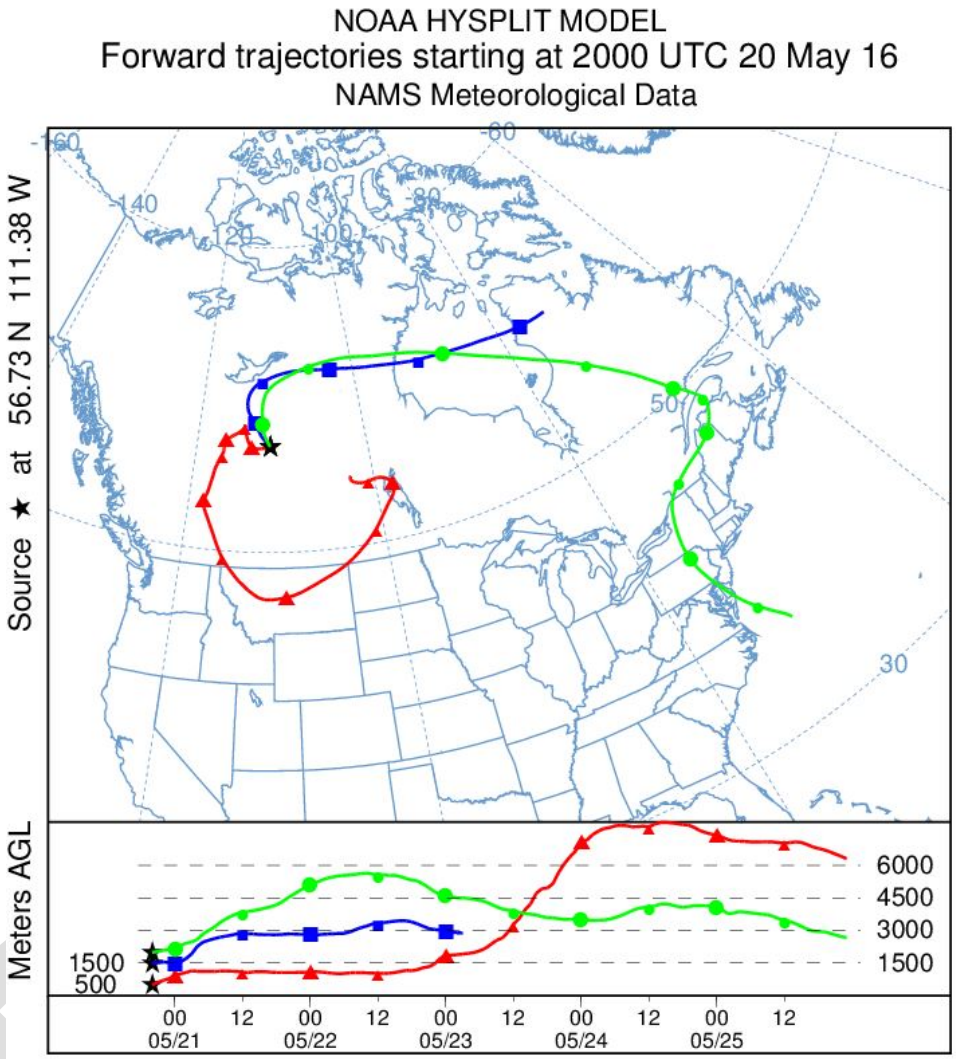


Figure 106: 150 Hour Forward Trajectories Starting at 2000 UTC 20 May 16



x. Satellite imagery of plume with evidence of the plume impacting the ground

The satellite imagery obtained during this exceptional event are shown in the following Figures 107 to 118. Elevated carbon monoxide and aerosol optical depth levels were observed in the Midwestern U.S. and these elevated levels were shown to move to the eastern U.S. as the event progressed. The additional evidence contained in this section was supplied by the Maryland Department of the Environment. The red dots in Figure 107 show the location of all fires that were occurring in Canada, the U.S., and Mexico from May 17 to May 20, 2016. The location of these fires coincide with the exact direction of the winds on the days preceding the high ozone levels seen in New Jersey on May 25 and May 26. Figures 108 to 118 the location of the smoke cloud, as determined by HMS, is overlayered with isopleths of the daily maximum ozone concentrations, and show the progression of the high ozone levels across the country from May

18 – 28, 2016. The smoke cloud is represented by the hatchmarks and the level of ozone air quality corresponds to the colored areas. Elevated ozone levels are directly related to the movement of the smoke cloud across the country.

Figure 107: The Location of All Wildfires in the U.S., Mexico, and Canada from May 17 to May 20, 2016

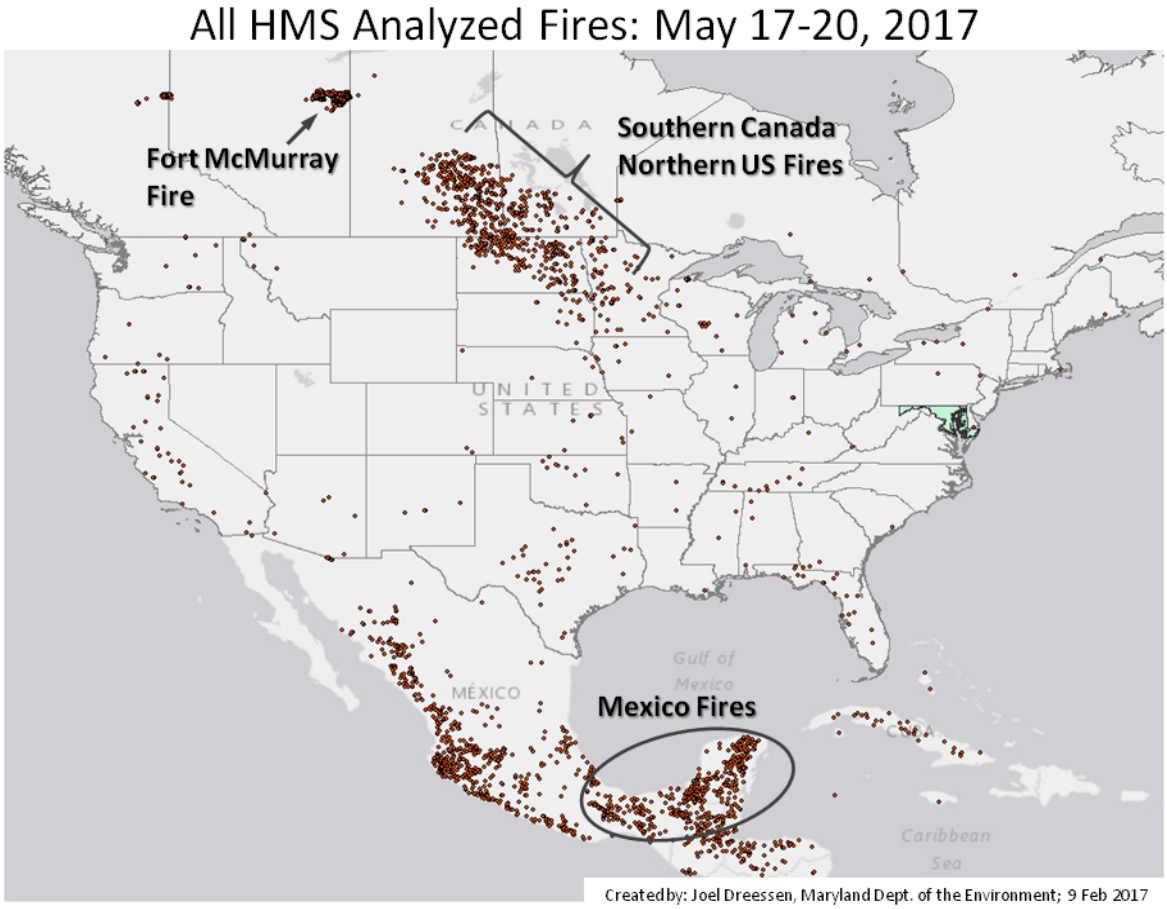


Figure 108: Overlay of Smoke Plume and Ozone Levels, May 18, 2016

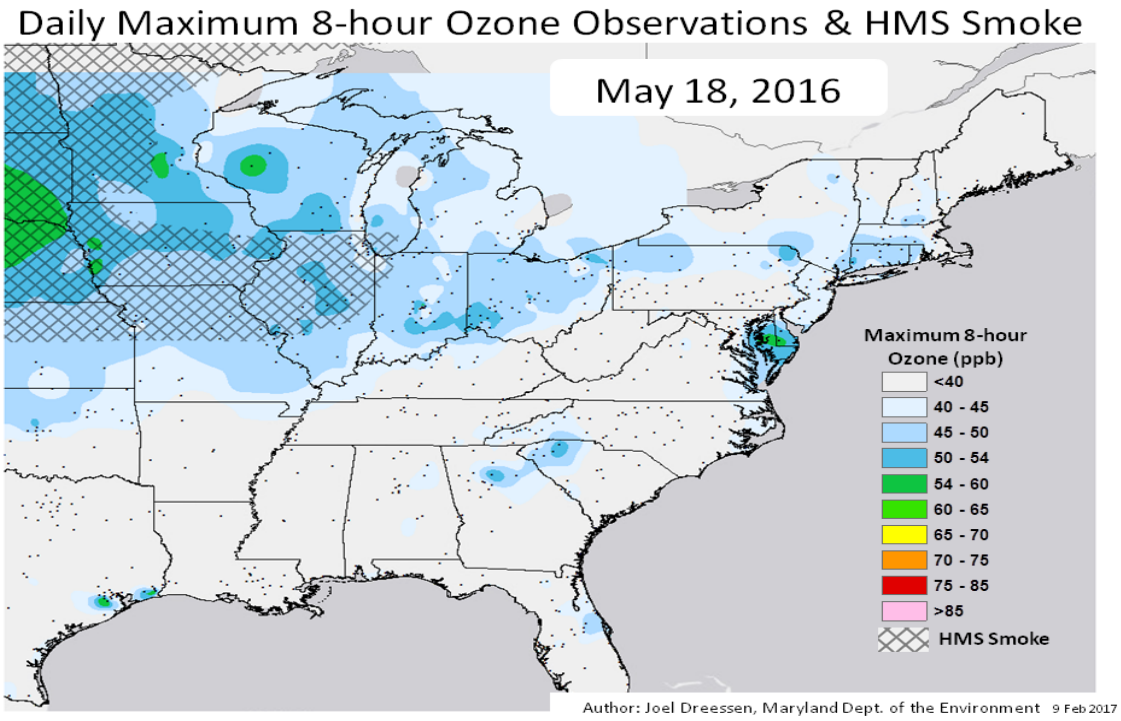


Figure 109: Overlay of Smoke Plume and Ozone Levels, May 19, 2016

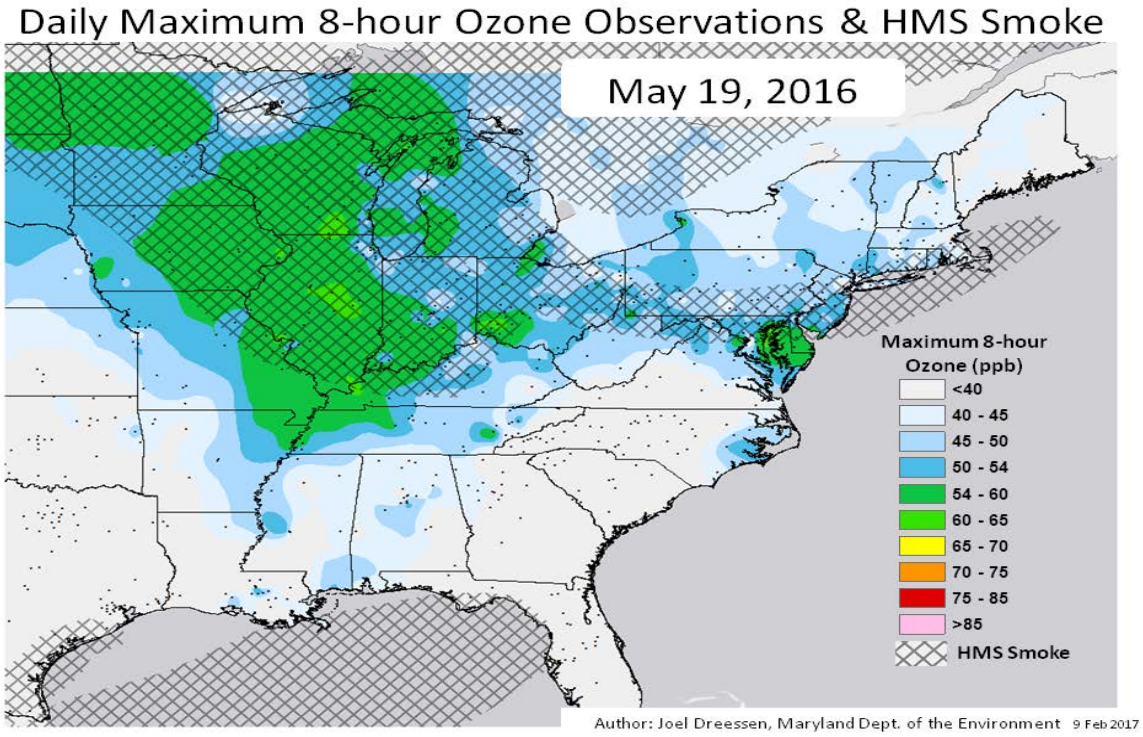


Figure 110: Overlay of Smoke Plume and Ozone Levels, May 20, 2016

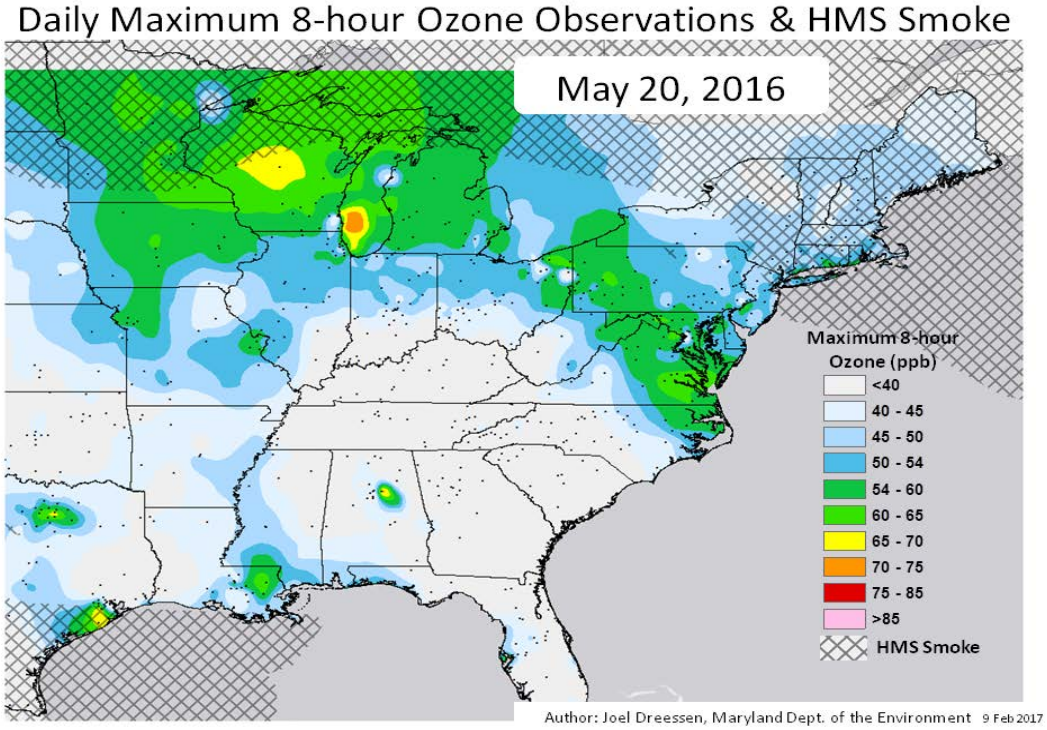


Figure 111: Overlay of Smoke Plume and Ozone Levels, May 21, 2016

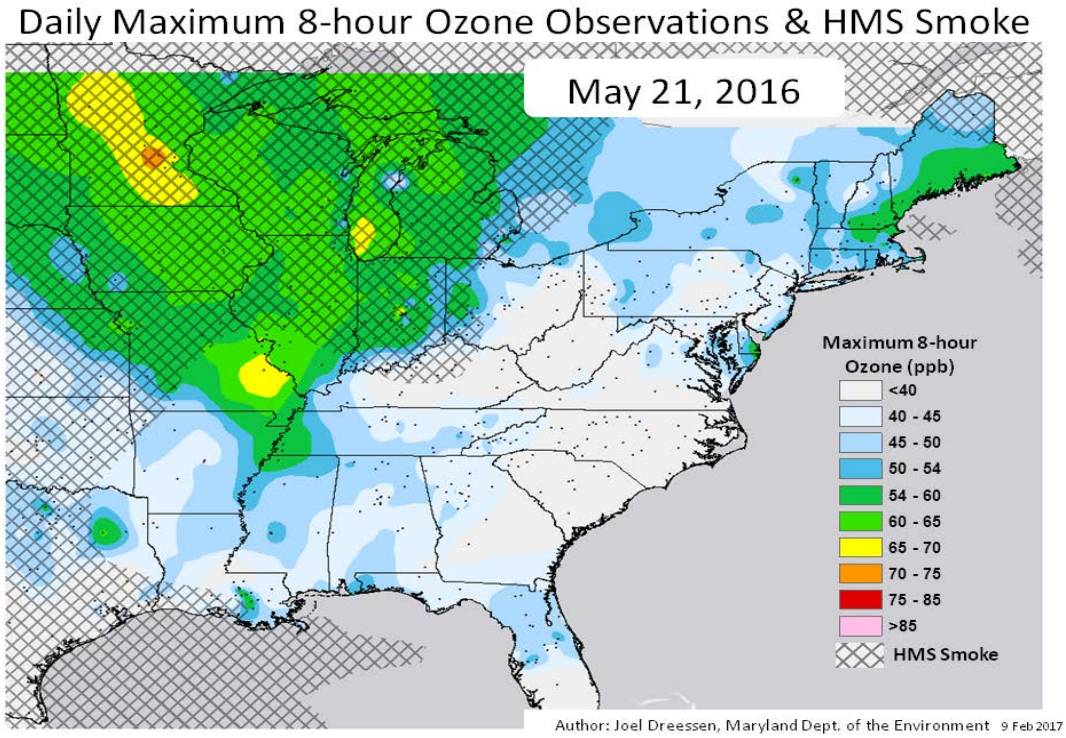


Figure 112: Overlay of Smoke Plume and Ozone Levels, May 22, 2016

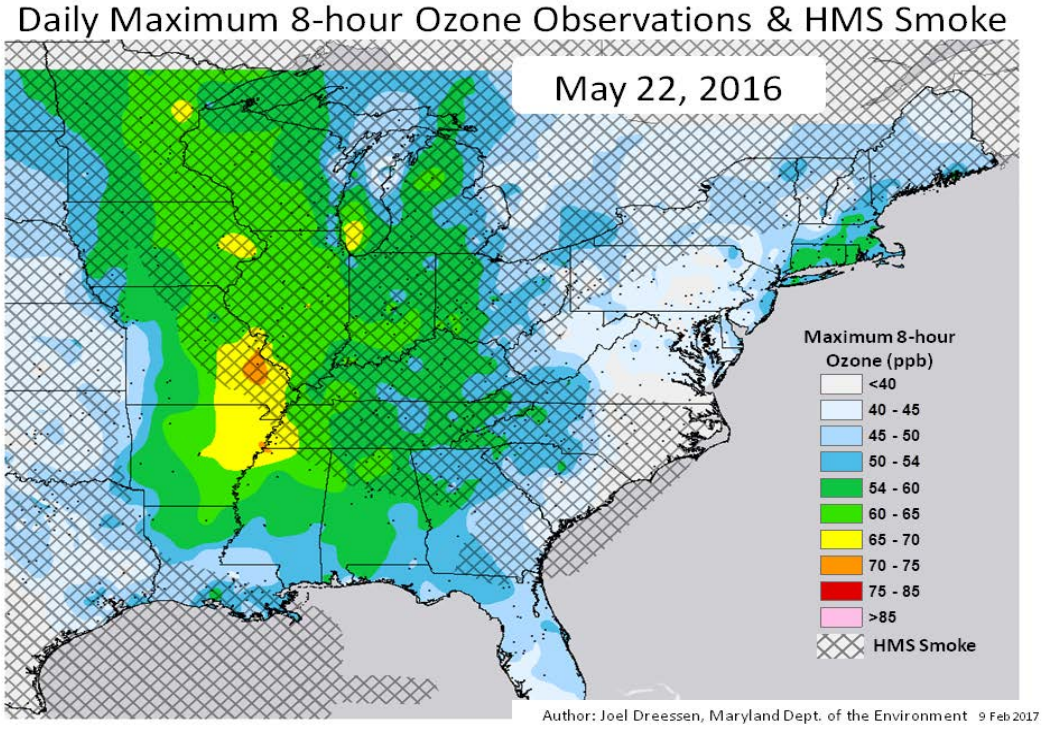


Figure 113: Overlay of Smoke Plume and Ozone Levels, May 23, 2016

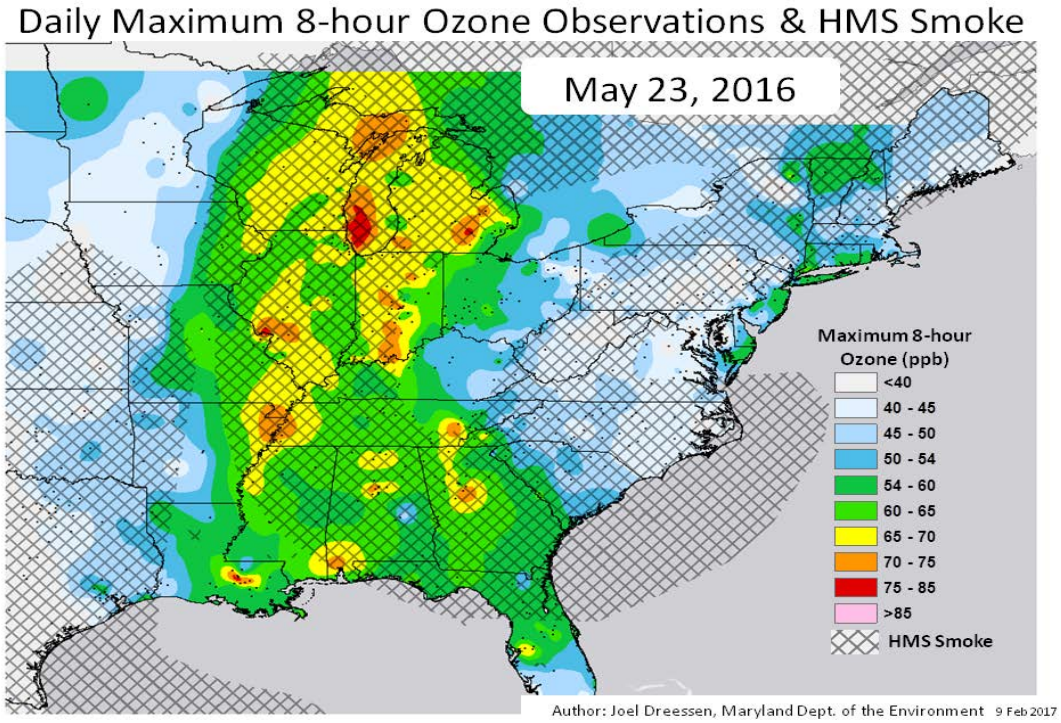


Figure 114: Overlay of Smoke Plume and Ozone Levels, May 24, 2016

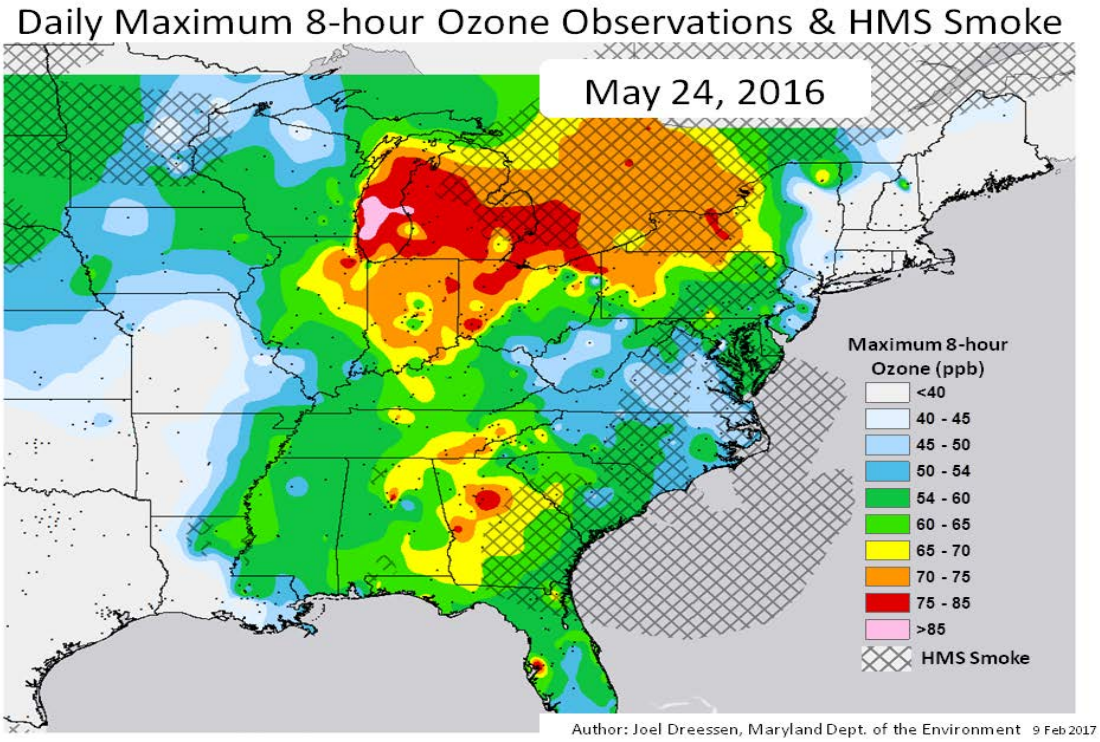


Figure 115: Overlay of Smoke Plume and Ozone Levels, May 25, 2016

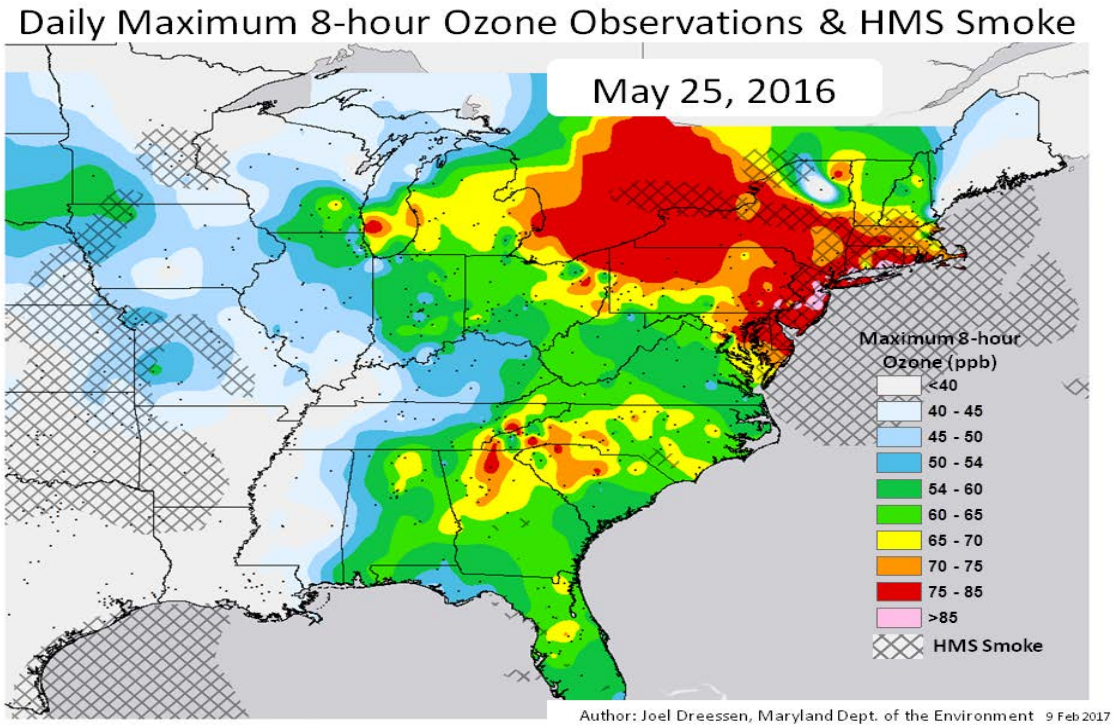


Figure 116: Overlay of Smoke Plume and Ozone Levels, May 26, 2016

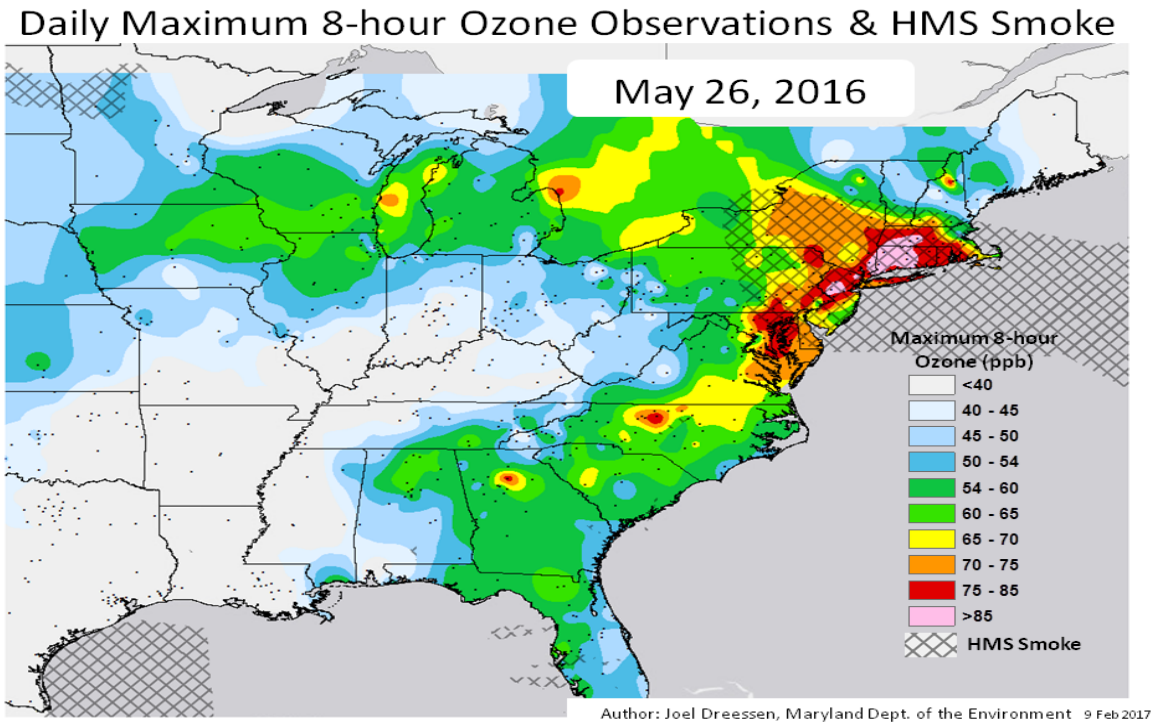


Figure 117: Overlay of Smoke Plume and Ozone Levels, May 27, 2016

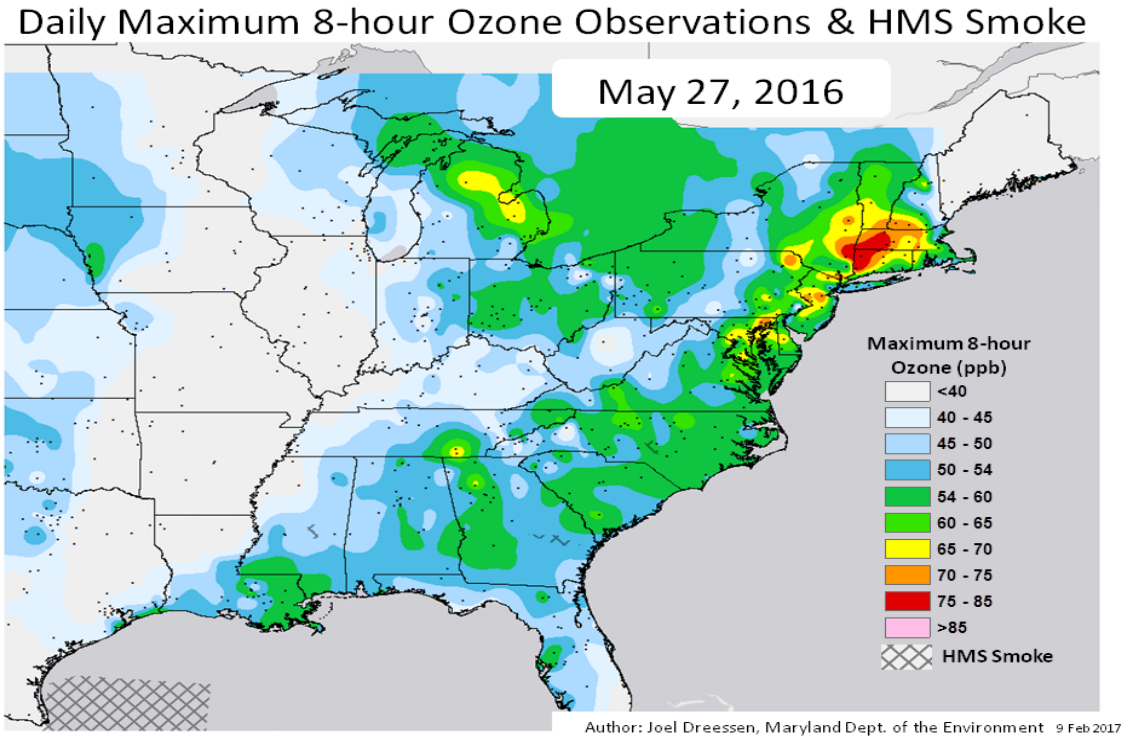
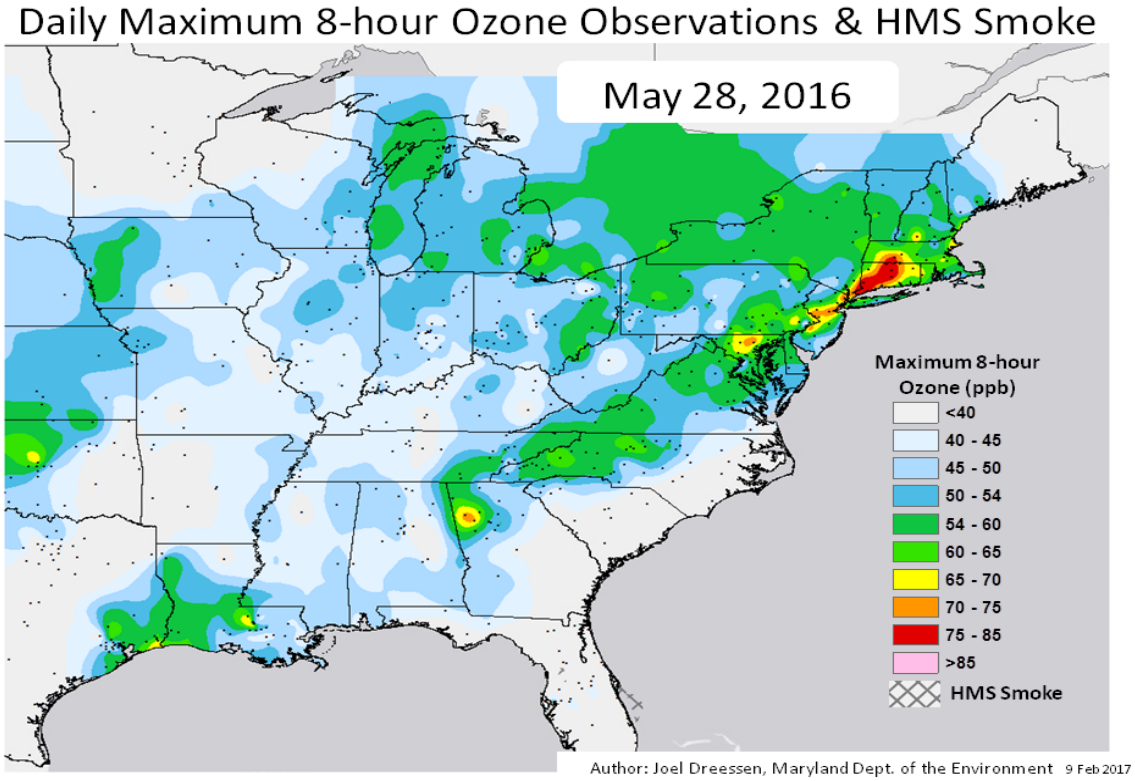


Figure 118: Overlay of Smoke Plume and Ozone Levels, May 28, 2016



3. Wind roses on days of exceptional event compared to 10-year average summer season wind rose

Wind roses on the day of this event compared to average summer season wind roses would not be a significant factor in the analysis of this exceptional event. The smoke emissions from the Canadian wildfire originated in a location several hundred miles away from New Jersey and several days before high ozone levels were experienced in New Jersey. HYSPLIT trajectory analysis going back several days is a more appropriate indicator of where the wildfire emissions originated than a wind rose on just the day of the exceptional event. The wind rose, therefore, was excluded from this analysis.

IV. A Demonstration That the Exceptional Event was Both Not Reasonably Controllable and Not Reasonably Preventable Including News Reports or Notifications to the Public Characterizing the Nature of the Fire and Our Explanation of the Origin and Evolution of the Fire

The EPA's Exceptional Events rule accepts that wildfire events on wildland are not generally reasonable to control or prevent. The news articles previously cited in this document state that the fire occurred on wildland and that it is likely caused by a human accident. New Jersey is not aware of any evidence clearly demonstrating that prevention or control efforts beyond those actually made would have been reasonable. Therefore, emissions from this wildfire were not reasonably controllable or preventable.

V. A Demonstration That the Exceptional Event was Caused by Human Activity That is Unlikely to Recur at a Particular Location or was a Natural Event and Identify the Origin and Devolution of the Wildfire and the Burned Area is a Wildland According to the Exceptional Event Rule Definition

The Fort McMurray wildfire can be considered a natural event. The definition of a wildfire in the EPA's Exceptional Events rule is "…any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event."

According to the July 5, 2016 press release from the CBC news[23], while investigators believe the fire was started by humans, it's still not known exactly how it began. Another more recent source[24] stated:

> "An official cause of the fire has not been determined to date, but it is suspected to be human caused, starting in a remote area 15 kilometers (9.3 mi) from Fort McMurray. During the start of the fire, an unusually hot, dry air mass was in place over Northern Alberta, which brought record-setting temperatures to Fort McMurray. On May 3, the temperature climbed to 32.8 °C (91 °F), accompanied by relative humidity as low as 12%. The situation intensified on May 4 when temperatures reached 31.9 °C (89 °F) and winds gusted to 72 km/h (45 mph). This significantly contributed to the fire's rapid growth. The winter preceding the fires was drier than usual, leaving a paltry snowpack, which melted quickly. Combined with the high temperatures, this created a "perfect storm" of conditions for an explosive wildfire.
>
> Daniel Thompson, a fire research scientist with Natural Resources Canada in Edmonton, told Bloomberg News that the natural El Niño cycle led to a dry fall and winter season along with a warm spring. The weather condition affects fires in a number of regions including Indonesia and northwest United States and Canada. Similar events occurred in 1997–1998. Fire is a natural and necessary component of boreal forest ecosystems."

[23] http://www.cbc.ca/news/canada/edmonton/fort-mcmurray-wildfire-now-considered-under-control-1.3664947
[24] https://en.wikipedia.org/wiki/2016_Fort_McMurray_wildfire

The area surrounding Fort McMurray is boreal forest, which consist mainly of spruce trees, pine trees, and aspen trees that need to periodically be burned to regenerate themselves. Those species have adapted to fire and their cones have adapted to open up after the fire. As this wildfire was quite extensive, much of the trees and plant growth in the area surrounding Fort McMurray were completely burnt. A wildfire would not likely reoccur in the near future due to the extensive nature of the fire consuming much of the burnable forest growth.

Based on the review of the literature available in the press concerning the Fort McMurray fire, the event qualifies as a wildfire because either human error or a natural cause of ignition caused an unplanned wildfire event. The EPA generally considers the emissions of ozone precursors from wildfires on wildland to meet the definition of a natural event at 40 CFR 50.1(k), defined as one 'in which human activity plays little or no direct causal role.' This wildfire occurred on wildland as documented by the news media and accordingly, NJDEP has shown that the event is a natural event and may be considered for treatment as an exceptional event.

VI. Documentation of the Public Comment Process

This document was made available for public comment by posting it on the NJDEP website (http://www.state.nj.us/dep/) on (date). The comment period was open for 30 days and ended on (date). The comments received and New Jersey's responses are included below. A final version of this document is also posted on the NJDEP's website.

VII. Conclusion

On May 25 and 26, 2016, a wildfire event occurred in Fort McMurray, Alberta, Canada that generated volatile organic compounds, black carbon, fine particulate matter, carbon monoxide, nitrogen oxides, potassium, haze and other products of combustion. The emissions from this wildfire event resulted in elevated concentrations of ozone in New Jersey's air. The monitored ozone concentrations were greater than the 98th to 99th percentile highest concentrations for ozone recorded in New Jersey over the past five years. Meteorological conditions were not consistent with historically high ozone concentrations. The comparisons and analysis presented in Sections II and III of this document support NJDEP's position that the wildfire event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedances of the ozone NAAQS on May 25 and 26, 2016 and thus satisfies the clear causal relationship criteria established by the EPA for this to be considered an exceptional event. Therefore, the ozone data measured at New Jersey monitors on May 25 -26, 2016 are due to an exceptional event and should be excluded from the calculation of the 2016 ozone design value.